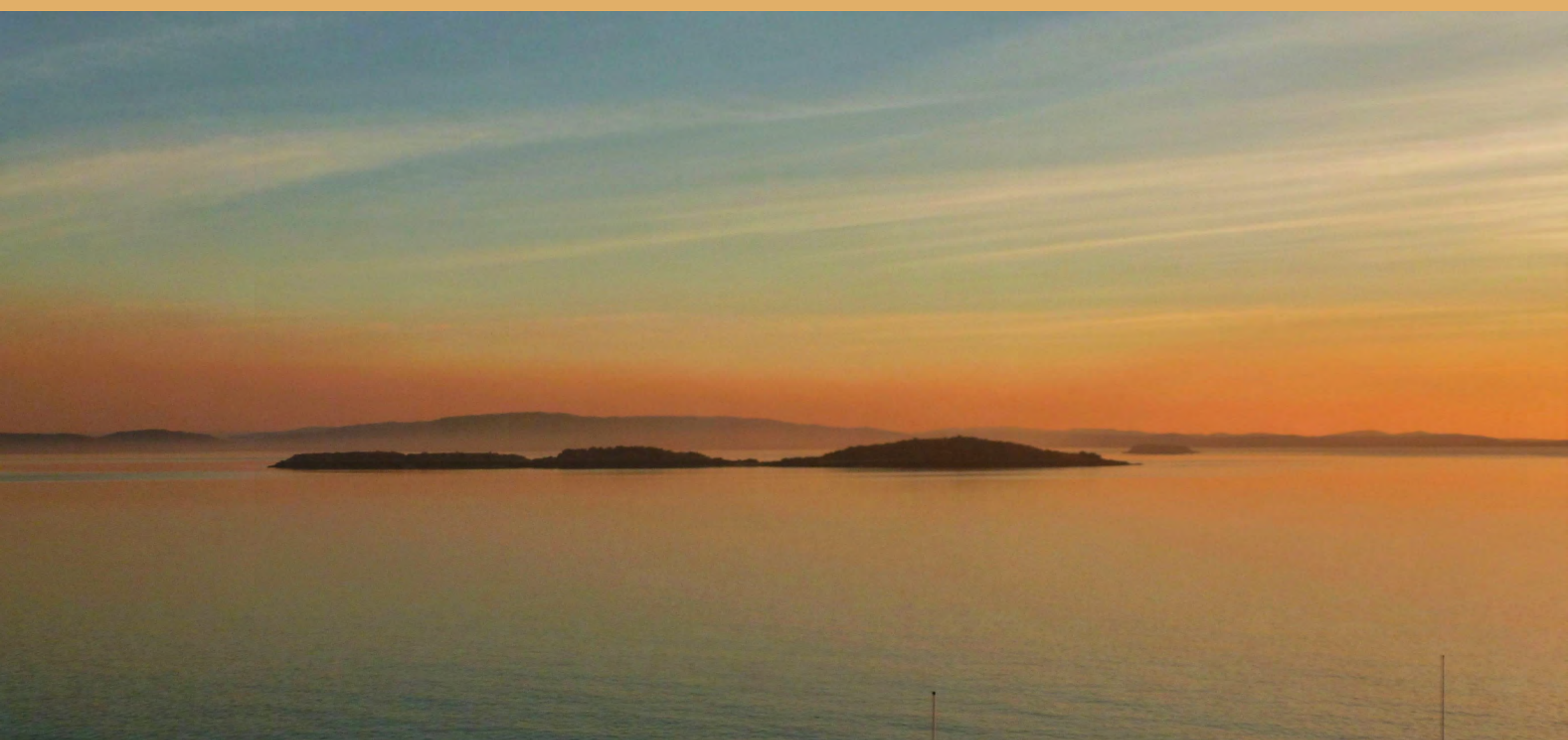
The Royal Society of Western Australia
Symposium 2018

Landscapes, Seascapes & Biota: Unique WA – Past, Present & Future

Program & Abstracts



July 27 & 28 2018

University Club, The University of Western Australia

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The Royal Society of Western Australia Symposium 27–28 July 2018

LANDSCAPES, SEASCAPES & BIOTA: UNIQUE WA – PAST, PRESENT & FUTURE

PROGRAM & ABSTRACTS

University Club, The University of Western Australia, Entrance 1, Hackett Drive, Crawley

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The Royal Society of Western Australia (RSWA) is the one of the oldest multi-disciplinary science organisations in Western Australia. It was established in 1914 and formed from precursor societies dating from 1897. The Society fosters exchange among scientists and promotes science in all its aspects, through publications, meetings, symposia and special events. The Society also honours and encourages outstanding achievement in Western Australian science through a number of awards.

At the core of the society is the Journal of the Royal Society of Western Australia (established in 1914 as a succession to Journals dating from 1899), a peer-reviewed journal that publishes original scientific research with an emphasis on local science. The journal has a broad scope that covers all branches of the natural and physical sciences, as well as anthropology and archaeology. Special issues with collected papers on a selected topic within the scope of the journal are occasionally published.

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PROGRAM

Friday 27 July 2018

8.30–9.00: Morning Coffee/Tea

9.00–9.30: **1. Opening of Symposium**: Dr David Haig, President RSWA (Auditorium)

SESSION 1 (Auditorium: Chair – Professor Myra Keep)
9.30–10.00: **2.** Keynote talk: **The Archean of WA: from the earliest crust to the onset of life on Earth:** ***Simon Wilde, Arthur Hickman.***

10.00–10.30: **3.** Keynote talk: **The assembly and reworking of cratonic WA: a legacy of three supercontinent cycles**: ***Zheng-Xiang Li, Sergei Pisarevsky, Yebo Liu, Camilla Stark, Uwe Kirscher, Ross Mitchell***

10.30–11.00: **4.** Keynote talk: **Western Australia's Phanerozoic phases and phenomena: interrelationships between tectonics, climate and landscape over the last 540 million years:** ***Arthur Mory, David Haig***

11.00–11.30: **POSTERS** & Morning Tea (Banquet Hall)

SESSION 2 (Auditorium: Chair – Dr Arthur Mory)
11.30–12.00: **5.** Keynote talk: **News ways to image ancient environments in Western Australia:** ***Julien Bourget, Victorien Paumard***

12.00–12.30: **6.** Keynote talk: **New ways to image modern landscapes & seascapes:** ***Nik Callow, Sharyn Hickey, Ben Radford,***

12.30–1.30: **POSTERS** & Lunch (Banquet Hall)

SESSION 3 (Auditorium: Chair – Dr Eckart Håkansson)
1.30–2.00: **7.** Keynote talk: **The evolution of life: Its preservation across ocean anoxic events (and major mass extinction events) from biomolecules and geomolecules to cellular remains**: ***Kliti Grice, Ines Melendez, Chloe Plet, Roger Summons, Lorenz Schwark***

2.00–2.30: **8.** Keynote talk: **Microbiomes of Western Australian marine environments*: Charlie Phelps, Rachele Bernasconi, Melissa Danks, Josep Gasol, Anna Hopkins, Jacquelyn Jones, Christopher Kavazos, Belinda Martin, Flavia Tarquinio, Megan Huggett***

2.30–3.00: **9.** Keynote talk: **Fossil algae and testate protists in marine Phanerozoic environments of Western Australia: A record through latitudinal change, climate extremes and breakup of a supercontinent.** ***David Haig, Clinton Foster, Daniel Mantle, Richard Howe, John Backhouse, Daniel Peyrot***

3.30–4.00**: POSTERS** & Afternoon Tea (Banquet Hall)

SESSION 4 (Auditorium: Chair – Professor Kate Trinajstic)
3.30–34.00: **10.** Keynote talk: **Greening of WA landscapes: the Phanerozoic plant record: *Daniel Peyrot, Daniel Mantle, John Backhouse***

4.00-4.30: **11.** Keynote talk: **The Root Causes of Plant Diversity Hotspots in Western Australia**: ***Mark Brundrett***

4.30–5.00: **12.** Keynote talk: **Modern seagrass and macroalgal biogeography in WA, an update: *Diana Walker, John Huisman, Kieryn Kilminster, John Kuo***

Free Public Lecture: Friday 27 July 2018

6.30–7.30: **Assembling the Human Body Plan - A Tale Told By Fossils:** ***Professor John Long*** (The University Club Auditorium)

Saturday 28 July 2018

8.30–9.00: Morning Coffee/Tea

SESSION 5 (Auditorium: Chair – Dr. Mick O'Leary)
9.00–9.30: **13.** Keynote talk: **Major changes in WA shallow marine invertebrate faunas during the Phanerozoic - long and short-term controls: *Eckart Håkansson, Kenneth McNamara***

9.30–10.00: **14.** Keynote talk: ***Marine invertebrate biogeography of the North West shelf: A tribute to Barry Wilson*****: *Lisa Kirkendale, Andrew Hosie, Zoe Richards***

10.00–10.30: **15.** Keynote talk: **Invertebrates colonizing ancient landscapes - the Phanerozoic WA record: *Kenneth McNamara, Sarah Martin***

10.30–11.30: **POSTERS** & Morning Tea (Banquet Hall)

SESSION 6 (Auditorium: Chair – Dr Giada Bufarale)
11.30–12.00: **16.** Keynote talk: **Invertebrates in modern WA terrestrial and inland-water environments: *Mark Harvey, Kym Abrams, Catherine Car, Raphael Didham, Joel Huey, William Humphreys, Annette Koenders, Jonathan Majer, Melinda Moir, Adrian Pinder, Michael Rix, Nikolai Tatarnic***

12.00–12.30: **17.** Keynote talk: **Fossil vertebrates from ancient marine environments in Western Australia: *Mikael Siversson, Kate Trinajstic, John Long***

12.30–1.00**: 18.** Keynote talk: **Dinosaurs and other terrestrial and freshwater vertebrates from the Western Australian segment of ancient Gondwana***: Steve Salisbury, John Long***

1.00–1.10: Presentation of The Medal of the Royal Society of Western Australia to Professor Barbara York Main

1.10–2.00: **POSTERS** & Lunch (Banquet Hall)

SESSION 7 (Auditorium: Chair – Dr Margaret Smith)
2.00–2.30: **19.** Keynote talk: **Late Quaternary mammalian faunal responses to environmental change in South-West Australia**: ***Grant Gully, Gavin Prideaux***

2.30–3.00: **20.** Keynote talk: **Human origins in Western Australia:** ***Joe Dortch, Jane Balme, Jo McDonald, Kate Morse, Peter Veth.***

3.00–3.30: **21.** Keynote talk: **Runoff and groundwater responses to climate change in Southwest Western Australia**: ***Don McFarlane, Richard George, John Ruprecht, Steve Charles, Geoff Hodgson***

3.30–4.00**:** Afternoon Tea (Banquet Hall)

SESSION 8 (Auditorium: Chair – Dr Daniel Peyrot)
4.00–4.30: **22.** Keynote talk: **Progressing Western Australian collision with Asia: implications for regional orography, oceanography, climate and marine biota:** ***Myra Keep, Ann Holbourn, Wolfgang Kuhnt, Stephen Gallagher***

4.30–5.00: **23.** Keynote talk: **Old climatically-buffered infertile landscapes and seascapes yield new perspectives on Western Australia's biodiversity and its conservation:** ***Steve Hopper, Hans Lambers, Tim Langlois***

5.00–5.30: **24.** Keynote talk: **Implications for Human communities from future environmental change in Western Australia**: ***Petra Tschakert***

President's Dinner

6.30-10.30 pm: **Three course meal and beverages provided. The Dinner will include presentation the Medal of the Royal Society of Western Australia to Professor David Blair and the Doug Clarke Medal to Mr Darren Hamley; and the announcement/presentation of the Symposium Poster Awards. Attendance is separately costed on Registration Form.** (Banquet Hall)

KEYNOTE TALKS: ABSTRACTS
FRIDAY 27 JULY

University Club Auditorium, UWA

Authors have sole responsibility for the content of their Abstract and talk

2. KEYNOTE TALK

The Archean of WA: from the earliest crust to the onset of life on Earth

Simon A. Wilde[1] and A.H. Hickman[2]

[1]Department of Earth & Planetary Sciences, Curtin University, Kent Street, Bentley, WA 6102.
[2]Geological Survey of Western Australia, Department of Mines, Industry Regulation and Safety, Plain Street, East Perth, WA 6004

The two major Archean crustal blocks in Western Australia – the Yilgarn and Pilbara cratons – are recognised globally for their significance in early Earth studies. The Yilgarn craton contains the oldest known remnants of continental crust in the form of Hadean (>4.0 Ga) detrital zircons from the Narryer Terrane, whereas the Pilbara craton hosts the world's best-preserved evidence for the rise of life on Earth between 3500 and 3350 Ma, with stromatolites, microfossils, and microbially induced sedimentary structures. In addition, both cratons contain some of the oldest and best preserved early rock associations, with the Eoarchean 3,730 Ma Manfred Complex and earliest components of the Meeberrie gneiss well exposed in the Narryer Terrane and the Pilbara containing some of Earth's oldest and best preserved volcanic and sedimentary successions of Paleoarchean (>3.2 Ga) age.

The Yilgarn Craton occupies an area of ca. 657,000 km^2 in central-south Western Australia and is currently subdivided into five granite-greenstone terranes and two terranes dominated by granites and gneisses. Of the latter, the Narryer Terrane occupies an area of ~30,000 km^2 in the northwestern Yilgarn Craton and is one of the earliest crustal terranes on Earth, containing rocks with U-Pb zircon ages ranging up to 3730 Ma, the oldest known rocks in Australia, and detrital zircon ages up to 4404 Ma, the oldest terrestrial material on Earth. Furthermore, zircon U–Pb and Lu-Hf data suggest initial crustal formation at ca. 4450 Ma, with extensive reworking until at least 2650 Ma, without major addition of juvenile material from the mantle.

The 3800–2830 Ma Pilbara Craton is a 400,000 km^2 segment of Archean granite–greenstone crust underlying the northwestern part of Western Australia. Over 70% of the craton is concealed beneath overlying 2775–2445 Ma volcano-sedimentary successions of the Fortescue and Hamersley Basins, but part of the northern half the craton is exposed as a 60,000 km^2 inlier. The eastern 40 000 km^2 of this inlier is mainly composed of Paleoarchean crust whereas the western half is largely Mesoarchean (>2.8 Ga) in age. The east Pilbara craton evolved by recycling of 3600–3500 Ma crust with very limited addition of juvenile material. Hafnium two-stage model ages of Eoarchean zircons suggest ca.4.0 Ga mantle extraction ages. Its typical dome-and-keel crustal architecture was the result of gravity-driven vertical deformation and initially formed between 3490 and 3220 Ma. Several intervals of erosion and sedimentation provided suitable environments for early life to evolve.

3. KEYNOTE TALK

The assembly and reworking of cratonic WA: a legacy of three supercontinent cycles

Zheng-Xiang Li, Sergei Pisarevsky, Yebo Liu, Camilla Stark, Uwe Kirscher and Ross Mitchell

Earth Dynamics Research Group, ARC Centre of Excellence for Core to Crust Fluid Systems (CCFS) and The Institute for Geoscience Research (TIGeR), School of Earth and Planetary Sciences, Curtin University

The Earth's history has been dominated by the assembly and breakup of three supercontinents since 2 Ga: the Mesoproterozoic Nuna (1.6–1.4 Ga), the Neoproterozoic Rodinia (900–700 Ma) and the Phanerozoic Pangaea (320–170 Ma). Accompanying the supercontinent cycles has been the operation of modern-day-like plate tectonics, and the beginning of degree-1 or degree-2 long-wavelength whole-mantle convection. Before then, the Earth went through a stage of rapid continental growth and the assembly of major cratons. Here we examine the assembly and reworking of cratonic Western Australian in such a global context.

The Archaean Yilgarn and Pilbara cratons were separate continental blocks before Nuna time, but assembled together by ca. 1950 Ma to form the West Australian Craton (WAC). Before then, the Pilbara craton was possibly joined with the Kaapvaal Craton of South Africa during the Archaean (the Vaalbara connection), whereas the Yilgarn Craton was possibly connected with the Zimbabwe Craton (the Zimgarn connection).

The Kimberley Craton joined the Proto-North Australian Craton by 1800 Ma to form the North Australian Craton (NAC). Then the WAC and the NAC joined together, possibly also with the South Australian Craton (SAC) and the East Antarctica – together the Mawson Craton, to form the Proto-Australian Craton soon after 1800 Ma. The 2000–1800 Ma period was a period of global cratonic amalgamation in the lead up to the eventual assembly of the supercontinent Nuna. The configuration of the Proto-Australian Craton, however, was rather different from that of the present-day cratonic Australia.

The Proto-Australian Craton joined Laurentia and possibly all other continental blocks to form possibly the first supercontinent, Nuna, at 1600 Ma. Nuna broke up after 1400–1300 Ma, but reassembled into the next supercontinent Rodinia by 900 Ma. Rodinia shared many similarities in its configuration with Nuna.

Continental rifting, possibly driven by mantle plume events atop of a mantle superplume, started ca. 850 Ma, leading to the breakup of Rodinia between 700 and 600 Ma. At the same time, the assembly of Gondwana started as a stage development for the assembly of the next supercontinent Pangaea. During the assembly of Gondwana, the Australian craton underwent a 40° intraplate rotation between NAC and the southern portion of the continent during the 650–550 Ma Paterson-Petermann Orogeny, forming the present-day configuration of the cratonic Australia.

4. KEYNOTE TALK

Western Australia's Phanerozoic phases and phenomena: interrelationships between tectonics, climate and landscape over the last 540 million years

A.J. Mory[1,2] and D.W. Haig[2]

[1]Geological Survey of Western Australia, Department of Mines, Industry Regulation and Safety, Plain Street, East Perth, WA 6004
[2]School of Earth Sciences, The University of Western Australia, Perth WA 6009

Phanerozoic strata extend offshore to the continental–ocean boundary, and are largely unmetamorphosed and little deformed as igneous rocks are minimal and orogenic events were subdued because of the passive margin – rift settings that persisted for nearly the entire eon. Regional correlations underpinned by paleontological studies and climatic indicators point to four main intracratonic phases of basin development during the Paleozoic, commencing with Cambrian synorogenesis and sag probably associated with the Centralian Superbasin. Ordovician to Early Devonian rifting–sag, coeval with early phases of the Alice Springs Orogeny in central Australia, was followed by renewed NNE–SSW extension spanning the Middle Devonian to mid-Carboniferous. Marine facies show some commonality between basins from this time onwards pointing to a western marine seaway, which eventually became the East Gondwanan rift. A regional Late Carboniferous hiatus is possibly due to an extensive ice sheet that inhibited sediment transport. As the ice melted latest Carboniferous – earliest Permian deglacial facies covered the State—they are the first deposits to transcend individual basins.

In the Permian an interior seaway along the east of the Southern Carnarvon Basin extended into the Perth Basin. Disruption of this seaway in the mid-Permian, associated with the separation of Cimmeria from the northwestern Gondwana margin, shifted depocentres to the present offshore part of the State, except in the Perth Basin. Around this time, other onshore basins became transit zones with minimal accommodation across which sediment moved west and northwest. Provenance studies indicate little apparent input from adjacent basement terrains suggesting thick overburden that eventually was deposited along the present North West Shelf throughout the Permian–Mesozoic. An onshore Late Triassic – Jurassic break in deposition was associated with separation from the East Gondwana margin of terrains now in southeastern Asia. Triassic–Jurassic deposition across the present onshore part of the State was dominantly thin highstand fluvial facies that encroached across older strata and basement. By comparison, far more complete (and better dated), dominantly deltaic to marine-shelf sequences were ubiquitous along the North West Shelf prior to continental breakup in the Late Jurassic – Early Cretaceous.

Breakup was the most significant deformation event during the Phanerozoic affecting most basins and uplifting adjacent basement terrains. Breakup left little trace across the Canning Basin possibly due to its structural grain being nearly orthogonal to that of the North West Shelf. Following breakup sediment derived from adjacent basement terrains increased substantially and marine deposition extended across most basins. By the mid-Cretaceous central Australia was briefly flooded with marine deposits significantly shallower-water and thinner than along the North West Shelf. In the Late Cretaceous Antarctica began to separate from Australia. As open-marine circulation surrounded the continent thick carbonate wedges built the present continental shelves while onshore was shaped by fluvial and weathering processes. The collision with the Indonesian Plate that commenced about eight million years ago will eventually reshape much more of our continent.

5. KEYNOTE TALK

News ways to image ancient environments in Western Australia

Julien Bourget and Victorien Paumard

School of Earth Sciences, The University of Western Australia, Perth WA 6009

Seismic reflection technology is a geophysical methodology used by geologists to image and map geological features in subsurface areas where direct rock observations are limited or not possible. Three-dimensional (3D) seismic methods allow imaging the subsurface at very high resolution (< 25 m), and thus allows imaging fine-scale objects such as buried river channels, submarine canyons, or ancient carbonate reefs. 3D seismic datasets are almost exclusively acquired by the oil and gas industry, and they have been the industry standard for finding oil and gas deposits since the late 1980s. These methods became accessible to academia in the later part of the 2000s, and now constitute a major research tool in Earth Sciences. 3D seismic research has led to major scientific advances in a wide range of disciplines ranging from structural geology and sedimentary processes, igneous geology, fluid-rock interactions, and paleo-environmental analysis. For those reasons, 3D seismic technology is considered as one of the most important scientific development in Earth Sciences of the last century.

Due to the abundance of hydrocarbon (oil and gas) resources offshore Western Australia over 350 3D seismic surveys were acquired in this region. As a result, the subsurface geology of offshore WA (from the modern seabed to > 6 km in subsurface depths) can now be resolved at a resolution < 25 m over an area spanning > 400,000 km^2. This extraordinary amount of geological data is made publicly available by the Australian government and thus accessible for academic research. Over the last decade, researchers from the University of Western Australia have interpreted this extensive seismic database using innovative computational and 3D imaging tools. Through this work our group has been able to reconstruct the palaeo-environments of the margins of Western Australia through the last 200 million years. This allowed understanding how our coastlines and oceanic basins responded to major plate-tectonic reorganization, changes in global climate and varying sea levels.

In this presentation we will highlight two of these discoveries: (1) how the separation of Australia with India led to the formation of extensive river deltas in the late Jurassic, and (2) how the subsequent marine flooding and warming climate led to the growth of a long-lived (> 20 Myrs) western Australian "Great Barrier Reef".

6. KEYNOTE TALK

New ways to image modern landscapes and seascapes

J.N.S. Callow [1], S. Hickey[1,2] and B. Radford[1,2]

[1]School of Agriculture and Environment, University of Western Australia, Perth, Western Australia
[2]Australian Institute of Marine Science, Indian Ocean Marine Research Institute, Perth, Western Australia.

Imagery has been central to how we document and understand our origins and history, the present, and predict and manage the future of our landscapes and seascapes. Australia's first peoples living in these landscapes acquired knowledge from continually travelling across the land and the sea, passing down knowledge in dreaming and as imagery through their art. European settlers travelled, observed, surveyed and assessed the land, coast and sea from the perspectives of resources, capacity and opportunities, much of which was documented in the journals, paintings, maps and early photography. These phases of imagery are an incremental resource that documents the rich and evolving physical and human history. Pieced together, they provide an understanding of the processes and lineage shaping modern landscapes.

The age of digital information is this next genesis in our increment understanding of landscapes and seascapes. Images generated with modern remotely operated technologies such as satellites, drones, remote and underwater cameras and sensors provide opportunities to capture these environments in unprecedented scale and detail, but need to build on traditional and colonial knowledge. It is critical that these new technologies to image modern landscapes and seascapes, are faithful to this history, and are applied within a robust framework focused on the questions and advancement of new knowledge, rather than simply applying new imaging technologies.

Here, we present a geographical framework for imaging both modern landscapes and seascapes. This framework considers the environment, economy, society and the central role imagery plays in documented state, change and process when framing the selection and use of imaging technologies. We present examples from the terrestrial, near-shore and off-shore, spanning the Holocene to the present day and identifying how imaging can play a role in advancing our fundamental understanding of landscapes and seascapes spanning including cyclone deposits, mangroves and reef environments.

7. KEYNOTE TALK

The evolution of life: Its preservation across ocean anoxic events (and major mass extinction events) from biomolecules and geomolecules to cellular remains

Kliti Grice[1], Ines Melendez, Chloe Plet, Roger Summons and Lorenz Schwark

[1] WA-Organic and Isotope Geochemistry Centre, Department of Chemistry, Chemistry and Resources Precinct, Curtin University Perth, WA 6845

The largest mass extinction 'event' of life at the close of the Permian era occurred when climate forces led to low atmospheric oxygen levels and increases in concentrations of carbon dioxide and hydrogen sulfide gases. This end-Permian event is related to the formation of the supercontinent Pangea. Green sulfur bacteria were abundant in the upper water-column of the ancient seas at many locations showing that the hydrogen sulfide, on which green sulfur bacteria depend must have been widespread. Similar conditions have been invoked from biomarker and stable isotopic studies during all past episodes of rapid global warming and mass extinctions.

Novel biomarker and stable isotopes approaches have been applied to reconstruct the palaeoenvironmental setting of a Devonian aged fossiliferous deposit (Canning Basin, WA). Highly unusual carbonate concretions, form around the decaying soft tissue of e.g. fish and invertebrates. Biomarkers and stable isotopes derived from green sulfur bacteria and sulfate-reducing bacteria play a pivotal role in the preservation of the biolipids via hydrogen sulfide forming organosulfur compounds. This discovery of steroids including sterols derived from an individual Devonian fossil, bridges the disciplines of molecular fossil and isotope geochemistry to the paleontology. More recently we have demonstrated that an ichthyosaur vertebra of 183 million years old was found to contain cholesterol but also contains red and white blood cell-like structures and collagen. The small size of the red blood cells was attributed to an evolutionary adaptation to low oxygen levels in the atmosphere when the ichthyosaur lived.

8. KEYNOTE TALK

Microbiomes of West Australian marine environments

Charlie Phelps[1], Rachele Bernasconi[1], Melissa Dankes[2], Josep M. Gasol[1,3], Anna Hopkins[2], Jacquelyn Jones[4], Christopher R. J. Kavazos[2], Belinda C. Martin[5], Flavia Tarquinio[1] and Megan J. Huggett[1,6*]

[1] Centre for Marine Ecosystems Research, School of Science, Edith Cowan University, Australia

[2] Centre for Ecosystem Management, School of Science, Edith Cowan University, Australia

[3] Institut de Ciències del Mar, CSIC. Barcelona, Catalonia, Spain

[4] Trace and Environmental Laboratory, Curtin University, Australia

[5] School of Biological Sciences, The University of Western Australia, Australia

[6] School of Environmental and Life Sciences, The University of Newcastle, Australia

[*]Corresponding author: megan.huggett@newcastle.edu.au

While it may escape layman's appreciation, all ecosystems are teeming with microscopic life. Invisible to the naked eyes, the microbes are essential for the functioning of the biosphere. Microbes are key players in global biogeochemical cycles, produce around half of the world's oxygen, and are responsible for key transformations in the cycles of nitrogen, phosphorus, sulphur and iron and other metals. Microbes are abundant in seawater, and it is estimated that in the surface ocean alone, microbial biomass is more than fifty times that of whales. They are abundant and genetically diverse not only in the seawater itself, but also in sediments and associated with marine organisms. Despite their enormous importance, there has been very limited work in the oceans surrounding, and in the transitional waters of, Western Australia. We postulate that a full understanding of life in the ocean requires knowledge of the marine microbial taxa, their genomes, their activity, their biogeographical patterns, and their synergistic associations to themselves and to their eukaryotic hosts. A research agenda including these subjects will benefit our understanding of the marine environment and will facilitate including fast-sequencing techniques to be used as health diagnosis tools for both marine organisms and environments.

9. KEYNOTE TALK

Fossil algae and testate protists in the marine Phanerozoic of Western Australia: A record through latitudinal change, climate extremes and breakup of a supercontinent

David W Haig[1*], Clinton B Foster[2], Daniel Mantle[3], Richard Howe[1], John Backhouse[1] and Daniel Peyrot[1]

[1] School of Earth Sciences, The University of Western Australia, Perth WA 6009
[2] Research School of Earth Sciences, The Australian National University, Canberra ACT 2601
[3] MGPalaeo Geological and Stratigraphical Consultants, Unit 1, 5 Arvida St., Malaga WA 6090.

[*]*Corresponding author: david.haig@uwa.edu.au*

Algae and testate protists in Western Australian Cambrian–Neogene marine deposits are reviewed in terms of their broad occurrence. Known groups include organic-walled unicellular phytoplankton (mostly algae; acritarchs and dinoflagellates); calcareous unicellular algal phytoplankton (calcareous nannoplankton and calcareous dinoflagellate cysts); benthic calcareous macroalgae as well as the enigmatic *Tubiphytes*; testate protists including Foraminifera and Radiolaria; and groups of uncertain affinity including calcareous tests of Calcitarcha, tuberitinids, *Draffania*, and possible Charophyta. As well as the groups listed above, chitinozoans are included in this discussion although their biological group affinities are uncertain. The stratigraphic and geographic distribution of these fossil groups depended mainly on: (1) major evolutionary events; (2) latitudinal position from warm low latitudes in the Northern Hemisphere during the Early Paleozoic, to cold high latitudes in the Southern Hemisphere during the Pennsylvanian and earliest Permian, and later to warmer mid southern latitudes; and (3) the nature of the sedimentary basins and the seas that inundated these regions during phases of breakup of the Gondwana supercontinent. The basins developed within the interior of East Gondwana during the Paleozoic to middle Mesozoic and then along a continental margin newly formed by the progressive North–South opening of the Indian Ocean from the Middle Jurassic to Early Cretaceous. These changes in ocean configuration lead to a significant diversification of dinoflagellates, calcareous nannoplankton and foraminifera that are important stratigraphic guide fossils in the Jurassic to Cretaceous strata.

10. KEYNOTE TALK

Greening of WA landscapes: the Phanerozoic plant record

Daniel Peyrot[1], Daniel Mantle[2] and John Backhouse[1]

[1]School of Earth Sciences, The University of Western Australia, Perth WA 6009
[2]*MGPalaeo Geological and Stratigraphical Consultants, Unit 1, 5 Arvida St., Malaga WA 6090.*

Palynological evidence recovered from subsurface strata from the Canning Basin indicates a fossil floral record extending back to the Middle Ordovician. This record suggests the presence of one of the earliest terrestrial ecosystems supporting multicellular photosynthetic organisms (embryophytes). By the Late Devonian, macrofloral remains and rich palynofloral assemblages from the Canning and Perth basins suggest that lowland habitats were colonised by a diversified vegetation locally characterized by common to dominant arboreal forms attributed to progymnosperms and lycopsids. During the Carboniferous, the latter probably reached a dominant position in the terrestrial ecosystems. This inference is based on palynofloral characteristics of successions from the Perth, Carnarvon and Canning basins and coeval macrofloral assemblages from eastern Australia. The Permian macrofloras of Western Australia are accessible in various coal-bearing outcrops from the Collie Basin and the northern Perth Basin dominated by leaves referred to *Glossopteris*. The related plants inhabited lowland swamp habitats and produced characteristic bisaccate striate pollen grains, which often represent a common to dominant element of the associated palynological assemblages.

The Mesozoic (Mesophytic) flora of Western Australia shows significant changes with respect to its older counterpart and is characterized by the gradual appearance and/or more widespread distribution of families and higher taxonomical groups still counting extant representatives such as conifers, ginkgoales and cycadophytes. A significant turnover in the flora is suggested by the composition of Early-Middle Triassic palynofloral assemblages recovered from the Northern Carnarvon and Bonaparte basins. The change in the microfloral composition is characterized by the appearance of diverse monolete spores attributed to *Aratrisporites* and the omnipresence of bisaccate grains with a distinctive distal germinal aperture (e.g. *Falcisporites*). These meiospores were produced by an interesting group of small-sized coastal lycopsids with a near-cosmopolitan distribution and by a group of 'seed ferns' with a widespread distribution in Gondwana and particularly well represented in Australia, where they constitute the distinctive elements of the *Dicroidium* flora, named after their foliage remains. The Jurassic macrofloras of Western Australia are particularly well represented and includes representatives of extinct conifer families together with species that will constitute the typical elements of younger southern hemisphere mesic and subtropical forests. This pattern is also revealed by palynofloral assemblages which includes common to dominant pollen grains attributed to extinct (Cheirolepidiaceae) and modern families such as Podocarpaceae and Araucariaceae. Though the so-called 'Cretaceous terrestrial revolution', characterized by the appearance of flowering plants from the mid-Early Cretaceous onwards, found a good expression in various successions in northeastern and southeastern Australia, the record of early flowering plants is scarce in Western Australia. Palyno- (and macro-) floral assemblages of that interval typically include a diverse assortment of spore(-producers) attributed to Gleicheniaceae and Schizaeaceae and other ferns representing probably the herbaceous strata of a vegetation including the above-mentioned conifers as dominant floral components. The first appearance of elements that will include some of the typical extant Australian flowering plants such as Proteaceae and Nothofagaceae can be traced back to the Late Cretaceous. These plants will assume a dominant position in Western Australian vegetation through the Cenozoic and Quaternary. The composition of macro- and palynofloral assemblages of these intervals is characterized by fluctuating abundances of mesic/temperate groups (Podocarpaceae, Araucariaceae, Nothofagaceae…) and more xeric elements (Proteaceae, Myrtaceae) in relation with fluctuating climatic episodes.

11. KEYNOTE TALK

The Root Causes of Plant Diversity Hotspots in Western Australia

Mark Brundrett

School of Biological Sciences, University of Western Australia, 35 Stirling Highway Perth WA 6009

A global review of the distribution of plants with specialized nutrient acquisition strategies such as mycorrhizal roots revealed that Australia is unique globally and the southwest of Western Australia even more so. The first wave of mycorrhizal evolution resulted in arbuscular mycorrhizas (AM) in the first land plants, which are still the most common association today. The second wave peaked in the Cretaceous when most ectomycorrhizal (EM) and non-mycorrhizal (NM) families arose (Brundrett and Tedersoo 2018). Some new Australian lineages of EM or NM plants arose during the second wave in Gondwana, but others evolved more recently in Australia. These include lineages in the very diverse families Fabaceae and Myrtaceae where species have switched from AM to EM, retained both associations (EM-AM), or have NM cluster roots. This contradicts the normal situation of strong phylogenetic consistency for mycorrhizal associations within plant families. Plant families that include Novel and Complex Root (NCR) clades constitute the third wave of mycorrhizal evolution. NCR lineages show increasing speciation rates in the past 30 Ma coinciding with continental aridification after separation from Antarctica. They are even more diverse in the ancient landscapes of the Southwest Australian Floristic Region (SWAFR) than elsewhere in Australia. The SWAFR plant diversity hotspot has extremely old and infertile soils due to weathering and leaching of regolith in Australia for at least 200 Ma. Landscapes and soils in WA are also spatially complex, allowing greater opportunities for edaphic specialisation by plants and low rates of extinction due to landscape stability and refugia.

Despite strong correlation between low soil fertility and increasing dominance by NM plants with cluster roots, the overwhelming root evolution trend in Australia is for co-dominance of plants with EM, EM-AM, AM or NM roots in the oldest landscapes and most infertile soils. These trends explain why Australia is a global diversity hotspot for plants with specialised nutrition, with about one third of all species of EM plants, many NM plants with cluster roots, as well as a quarter of all carnivorous plants. Reasons for switching root types can potentially be determined by linking divergence dates for key groups of plants to the climate history of Australia, but soils and fire are also very important. More sampling of roots and their associated fungi in NCR clades are required to investigate these trends. The SWAFR is a unique model for studying the long-term impacts of climate change and soil degradation on plants and provides a preview of future soil conditions elsewhere on earth.

Brundrett MC, Tedersoo L. 2018. Evolutionary history and diversity of mycorrhizal symbioses. *New Phytologist* doi: 10.1111/nph.14976.

12. KEYNOTE TALK

New perspectives on seagrass and macro algal biogeography

Diana Walker[1], John Huisman[2], Kieryn Kilminster[3,1] and John Kuo[4]

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The widespread adoption of new methodologies, especially molecular techniques, has made dramatic changes to our understanding of how species of sea grasses and macro algae are classified and distributed. One consequence of this new paradigm is increased skepticism regarding biogeographic studies based on pre-molecular species records. The question of "what is a species?" has changed and requires reconsideration of previous assessments. In some instances, specimens previously regarded as a single species have been shown to represent multiple genetic lineages, an extreme example that of the red alga *Portiera hornemannii*, now thought to include 21 cryptic species in the Philippines alone, and possibly up to 96 species in the Indo-Pacific. Other reclassifications have sunk many species into one, or combined or reorganized genera. These changes in taxonomic concepts have implications for conservation and biogeographical assessments, but our understanding of many groups is still in its infancy and requires further work. How will the necessary research be carried out into the future, with increasing costs and decreasing staff availability?

These changes have legal implications, for example, in the implementation of the Australian Environmental Protection and Biodiversity Conservation Act (EPBC), the maintenance of species conservation programs, and the identification of introduced marine pests, especially cryptic species. How these will be addressed, in view of the practicalities of marine field research, remain to be seen. The scale of number of genera and species in algae and sea grasses are very different and the implications for both groups will be presented.

PUBLIC LECTURE

6.30 - 7.30 pm, Friday 27th July
UWA Club Auditorium

Assembling the Human Body Plan: A Tale Told by Fossils

Professor John Long

College of Science and Engineering, Flinders University, South Australia

Professor Long researches the early evolution of vertebrates in order to unravel the early stages of how the modern vertebrate body plan was assembled. Many parts of our human anatomy had their origins back in the Early Palaeozoic (540–350 million years ago). This was when jaws, teeth, paired limbs, ossified brain-cases, intromittent genital organs, chambered hearts and paired lungs all appeared in early fishes. For the past 30 years he has been collecting from the Gogo sites in northern Western Australia, where perfectly preserved 3-D fish fossils have yielded many significant discoveries, including mineralised soft tissues and the origins of complex sexual reproduction in vertebrates. Current research projects include describing new Late Devonian Gogo fishes and reconstructing their soft tissue anatomy (with Assoc. Prof. K. Trinajstic, Curtin Univ.), new Early Devonian placoderm (stem-gnathostomes) from the Taemas region, NSW (with Dr G.C. Young, ANU); and investigating the role of trace elements in mass extinction events (with Prof. Ross Large, U.Tas).

KEYNOTE TALKS: ABSTRACTS
SATURDAY 28 JULY

University Club Auditorium, UWA

Authors have sole responsibility for the content of their Abstract and talk

13. KEYNOTE TALK

Patterns of Phanerozoic marine invertebrate biodiversity in Western Australia

Eckart Håkansson and Kenneth J. McNamara

School of Earth Sciences, The University of Western Australia, Perth WA 6009

The marine invertebrate record in WA is controlled largely by sea-level changes recorded in a string of mainly interior sedimentary basins, now located along the western and southern margins of the continent. The record is patchy, yet very broad, with representatives of virtually all major fossil groups. The talk will present selected highlights.

Early Palaeozoic records are generally sparse. The earliest record is of an early Cambrian fauna in the Ord Basin, although only a single trilobite species, *Redlichia forresti*, has been described. The Great Ordovician Biodiversification Event fares little better, with essentially a single early to middle Ordovician fauna dominated by trilobites and graptolites in the Canning Basin. Silurian faunas comprise a sparse conodont fauna from borehole material.

Late Palaeozoic faunas are far more significant. The Late Devonian reef biota of the northern Canning Basin contains one of the richest invertebrate faunas of its age worldwide, with stromatoporoids, corals, trilobites, brachiopods, conodonts, goniatites and nautiloids. Recent research on the trilobites suggests the off-reef faunas were adapted to low nutrient conditions, with rapid increase in nutrient supply possibly contributing to the Late Devonian mass extinction events. Carboniferous and Permian sequences represent shallow water shelf communities dominated by brachiopods, bryozoans and echinoderms. The Early Permian fauna, in particular, comprise conspicuous elements of echinoderm meadows and unusually large, mostly endemic bryozoans.

A newly discovered early Triassic shallow marine assemblage in the Perth Basin comprise a mixture of marine and terrestrial species, providing a rare glimpse into the recovery of a broad spectrum of Mesozoic biota, subsequent to the end-Permian extinction. Middle Jurassic faunas in the Perth Basin are dominated by bivalves and ammonites showing affinities with faunas of the Tethyan realm. Cretaceous invertebrate faunas are most abundantly present in the passive margin carbonates dominating in the Southern Carnarvon Basin, particularly in the Giralia Anticline. The Late Maastrichtian Miria Formation has an extremely rich molluscan fauna, dominated by ammonites, bivalves and gastropods, many of which have cosmopolitan ranges. Recently, a hitherto unknown, very rich bryozoan fauna has been located in the Maastrichtian part of the underlying Korojon Formation, providing a very rare glimpse into the status of this phylum in the Southern Hemisphere.

Paleogene faunas in the Southern Carnarvon Basin represent shallow shelf carbonate faunas containing a rich bryozoan/echinoderm (echinoid and crinoid) fauna. The influence of the proto-Leeuwin current is reflected by the spread of many of these elements by the Eocene and Miocene to firstly the Eucla Basin in southern Australia, and then further eastwards.

14. KEYNOTE TALK

Marine invertebrate biogeography of the North West shelf: A tribute to Barry Wilson

Lisa Kirkendale, Andrew Hosie and Zoe Richards

Western Australian Museum, Welshpool, WA 6106

Situated centrally in the vast Indo west Pacific biogeographic region, the Australian North West Shelf (NWS) is a wide continental ramp extending over 2500 km in the eastern Indian Ocean. A number of significant ecological features occur in the region including World Heritage Listed Ningaloo Reef, Ashmore Reef, 80-mile beach, Camden Sound, Scott Reef and the Rowley Shoals, as well as the recently mapped ancient submerged coastline. Oceanographic regimes vary greatly and include tide-dominated settings in the north to wave dominated settings in the south, oligotrophic conditions offshore and eutrophic conditions inshore. This combination of environmental heterogeneity and the influence of fluctuating sea levels over the last interglacial period have resulted in this expansive marine region supporting a wide variety of marine life with differential patterns of connectivity and speciation. We will discuss recent biodiversity and biogeographic research on marine invertebrates conducted by the WA Museum, with a focus on comparing trends among reef-building corals, macromolluscs and decapod crustaceans. First, we will examine the similarity of North West Shelf fauna to neighbouring areas, nationally and internationally, second, we will consider the latitudinal attenuation in diversity and last, we will examine inshore and offshore patterns of endemism. We will discuss how focussed taxonomic study has reinforced previous biogeographic hypotheses of faunal affinities but also where new explanations are needed to explain emerging patterns. We highlight gaps in our existing knowledge of this region and discuss threats to biodiversity along the shelf. The late Barry Wilson dedicated much of his life to the study and conservation of this enormous marine diversity hotspot and we dedicate this talk to him.

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15. KEYNOTE TALK

Invertebrates colonizing ancient landscapes – the Phanerozoic record in Western Australia

Kenneth McNamara[1] and Sarah Martin[2]

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[2]Geological Survey of Western Australia, Department of Mines, Industry Regulation and Safety, Plain Street, East Perth, WA 6004

Evidence for Palaeozoic terrestrial invertebrate faunas in W. A. is confined to early Palaeozoic rocks. The Mesozoic record, based on terrestrial arthropod faunas, is found in early Triassic and mid Jurassic sequences. Cenozoic records are rare, mostly from the Pleistocene and Recent, and consist of terrestrial gastropods and insects. The Palaeozoic trace fossil record in W. A. records some of the earliest evidence on Earth for the colonization of land. The fossils, made by arthropods, occur in the Tumblagooda Sandstone, which outcrops principally in the gorges of the Murchison River. Its age is inferred to be early to mid-Silurian. Two trace-fossil assemblages are recognised. One, consisting of burrows and arthropod trackways, represents a tidal/terrestrial ecosystem. Likely arthropod track makers include myriapods, eurypterids, euthycarcinoids and xiphosurids. A single euthycarcinoid body fossil is known. Evidence for terrestriality is provided by preservation of the tracks on wet sand surfaces, covered by fine, aeolian sand. A second trace fossil assemblage occurs in strata interpreted as having been deposited in a fluvial to marginal-marine environment. The Tumblagooda trace fossils support the view that colonisation of land by animals may have been from rivers, rather than directly from the sea.

Mesozoic records of terrestrial arthropods are restricted to insect fossils from the Lower Triassic Kockatea Shale and Lower Jurassic Cattamarra Coal Measures, both within the northern Perth Basin. Both insect assemblages are of interest globally: the Kockatea Shale as one of the few insect assemblages worldwide from immediately after the Permian–Triassic mass extinction, a key event in insect evolution; and the Cattamarra Coal Measures as one of very few insect assemblages known from the Jurassic of Gondwana. The Kockatea Shale assemblage is incompletely studied, but contains the earliest recorded 'blattoid' (cockroach stem-group) and aquatic hemipterans known from Australia. The best-preserved fossil in the collection is a complete tegmen (fore wing) belonging to Fulgoromorpha (Hemiptera: Auchenorrhyncha). In comparison, the Cattamarra Coal Measures insects have been well-studied. Although richly fossiliferous, preservation is generally poor. Eight separate insect orders have been identified — 'Blattodea', Grylloblattodea, Orthoptera, Hemiptera, Coleoptera, Neuroptera, Mecoptera and Diptera — with the Coleoptera the most common. The assemblage is strikingly similar to coeval insect assemblages from the Northern Hemisphere, suggesting a high level of faunal connectivity between the continents at this time.

16. KEYNOTE TALK

Invertebrates in modern WA terrestrial and inland-water environments

Mark Harvey[1], Kym Abrams, Catherine Car, Raphael Didham, Joel Huey, William Humphreys, Annette Koenders, Jonathan Majer, Melinda Moir, Adrian Pinder, Michael Rix and Nikolai Tatarnic

[1]Western Australian Museum, Welshpool, WA 6106

Invertebrates constitute the vast majority of multi-cellular life on Earth with an estimated 7–10 million species, the majority of which are undescribed. They are important components of virtually every ecosystem and are essential for a wide range of ecosystem services. Terrestrial and inland-water ecosystems are dominated by arthropods such as insects, arachnids and crustaceans, as well as soft-bodied groups like nematodes. Western Australia's environments include tropical vine thickets, deserts, gibber plains, sand plains, heathland, woodland, mesic forests, subterranean ecosystems, freshwater and saline wetlands and waterways. The region was largely blanketed by mesic forests until the formation of the Antarctic Circumpolar Current cooled and dried the region, particularly during the Neogene. Alternating wet and dry cycles drove ongoing diversification of the biota, and many invertebrate taxa have been shown to have radiated since the Miocene. While a lack of dated molecular analyses for most taxa precludes rigorous comparisons, we note that there is evidence of: (a) Mesozoic relicts such as onychophorans, some arachnids and fish; (b) Late Gondwanan clades such as freshwater crayfish; and (c) Late Tertiary clades such as some spiders and insects. Their age is often consistent with their occurrence in certain relictual habitats, with older lineages usually restricted to the high-rainfall south-west zone. Other taxa have made their way into Australia via dispersal from Asia once the Australian continental plate drifted close enough to allow faunal exchange. Subsequent colonisation and adaptation to the increasing aridification of Australian environments is exemplified by several groups, including epigean and subterranean representatives. The conservation status of many invertebrate taxa is of major concern, but there is a dearth of rigorous taxonomic treatments, ecological studies, life-history knowledge, and assessments of threatening processes for most taxa. The ongoing human-induced sixth mass extinction crisis is likely having an inordinate impact on invertebrates in Western Australia, particularly the iconic south-western region due to the synergistic effects of numerous threats.

17. KEYNOTE TALK

Fossil vertebrates from ancient marine environments in Western Australia

Mikael Siversson[1], Kate Trinajstic[2] and John Long[3]

[1]Western Australian Museum, Welshpool, WA 6106
[2] School of Molecular and Life Sciences, Curtin University, Perth, WA 6845
[3] College of Science and Engineering, Flinders University, South Australia

Ordovician fish plates are recorded from the Canning Basin in shallow marine sequences, and these are some of the oldest vertebrate remains known. Devonian vertebrates are especially diverse and well–preserved from the marine reef sequences of the Canning Basin, notably from the Frasnian Gogo Formation. Nearly 50 species of fishes are recognised from 3D preserved skeletal remains, and in some cases exceptional soft tissue preservation. These are largely represented by placoderms (extinct armoured fishes) and bony fishes (osteichthyans), with rarer occurrence of sharks and stem-chondricthyans (acanthodians). The Gogo fauna has played a major role in elucidating big events in the early vertebrate evolution, such as the origin of air-breathing and reproductive strategies in the first jawed fishes, and the evolution of modern shark cartilage. Other faunas are well-documented from the Canning Basin sequences, including Famennian microvertebrates and placoderms, and diverse Early Carboniferous chondrichthyan microfaunas. Exceptional occurrences include the world last thelodonts (jawless fishes). Permian sharks are known from isolated teeth and tooth whorls from the Carnarvon Basin, notably the large edestid *Helicoprion* is recorded here.

Triassic to Neogene vertebrates have been collected from many marginal- to open-marine deposits in Western Australia. Three of the sampled intervals stand out as particularly productive: (1) the Lower Triassic Blina Shale, known primarily for its amphibians; (2) the Lower Cretaceous Windalia Sandstone Member of the Muderong Shale, yielding abundant isolated bones and partial skeletons of ichthyosaurs and plesiosaurs; (3) the mid-Cretaceous Gearle Siltstone, rich in chondrichthyan remains.

Although Cenozoic strata are largely unexplored for marine vertebrates, preliminary surveying in Cape Range has produced encouraging results. The presence of comparatively common, large-sized teeth of *Carcharocles megalodon* in the Middle Miocene Pilgramunna Formation implies an abundance of vertebrates further down the food chain.

Recent collecting efforts in the Cretaceous northeast of Kalbarri have focused on sediment bulk sampling of the 'Vraconnian' to upper Cenomanian part of the Gearle Siltstone and an interval in the overlying Haycock Marl straddling the Cenomanian/Turonian boundary. These mid- to outer-neritic deposits have yielded rich elasmobranch faunas, with roughly 30 species recorded from each sampled unit, numerous taxa of bony fish, rare ichthyosaur and turtle remains and possible bird material.

18. KEYNOTE TALK

Dinosaurs and other terrestrial and freshwater vertebrates from the Western Australian segment of ancient Gondwana.

Steven W. Salisbury[1] and John A. Long[2]

[1] School of Biological Sciences, The University of Queensland, St Lucia Queensland

[2] College of Science and Engineering, Flinders University, South Australia

Western Australia provides important insights into the nature of Australia's terrestrial vertebrate fauna during the Mesozoic not otherwise known from other parts of the continent. Although all the described dinosaurian body fossils are indeterminate and derive from shallow marine deposits, significantly they include material from the Middle Jurassic and Upper Cretaceous.

Ozraptor subotaii, named on the basis of a partial tibia from the Middle Jurassic (Bajocian) Colalura Sandstone near Geraldton, is Australia's oldest non-avian theropod taxon and the only one from the Jurassic, while the partial humerus of a coelurosaurian from the Upper Cretaceous (Maastrichtian) Miria Formation in the Giralia Range, is the youngest. Other non-avian theropod fossils include an isolated caudal vertebra from the Lower Cretaceous (Hauterivian–Barremian) Birdrong Sandstone near Kalbarri, and a pedal phalanx found near Gingin in the Upper Cretaceous (Cenomanian-lower Turonian) Molecap Greensand. A caudal vertebra, also from the Colalura Sandstone, additionally points to the presence of a Middle Jurassic sauropod, potentially similar to *Rhoetosaurus brownei*.

Western Australia has also produced Australia's only Upper Cretaceous pterosaur body fossils. These include a jaw fragment of a possible ornithocheiroid from the Molecap Greenstone, and a partial ulna from the Miria Formation that may be Australia's only record of an azhdarchid. Although the body fossil record is frustratingly meagre, the Western Australian dinosaurian ichnofossil record is without parallel, and provides our only detailed look at Australia's dinosaurian fauna during the first part of the Lower Cretaceous. Continental deposits of the Valanginian–Barremian Broome Sandstone of the Dampier Peninsula preserve the world's most diverse dinosaurian ichnofauna, comprising at least 21 different types of tracks: five types of theropod tracks, at least six types of sauropod tracks, four types of ornithopod tracks, and six types of thyreophoran tracks. This globally unique ichnofauna indicates that the general composition of Australia's mid-Cretaceous dinosaurian fauna was already in place at the start of the Cretaceous. Both sauropods and ornithopods were diverse and abundant, and thyreophorans were the only type of quadrupedal ornithischians. Notable is the presence of large-bodied theropods, the immense sizes of some of the sauropods, the high diversity of ornithopods, including large-bodied forms reminiscent of hadrosauroids, and the high diversity and abundance of thyreophorans, among which is Australia's only definitive evidence of stegosaurians.

19. KEYNOTE TALK

Late Quaternary mammalian faunal responses to environmental change in southwestern Australia

Grant A. Gully and Gavin J. Prideaux

College of Science and Engineering, Flinders University, South Australia

Much of what we know about the prehistoric mammals of Western Australia, and how they were impacted by late Quaternary environmental changes, is derived from infill deposits in limestone caves of the Leeuwin–Naturaliste region in the extreme southwest. There have been three major phases of palaeontological research — the early 20th century, 1960–1970s and 1990–2000s — but the last summation of knowledge was published in 1984. This paper synthesises information from the published literature and museum records to review the fossil mammal record of the Leeuwin–Naturaliste region. Publications suggest a total a 63 mammal species are recorded from the Quaternary of the southwest, and museum records indicate mammal remains have been retrieved from 60 of the 61 caves known to have produced vertebrate fossils. Four cave deposits, two purely palaeontological (Tight Entrance Cave, Kudjal Yolgah Cave) and two archaeological (Devils Lair, Tunnel Cave), have been particularly well studied over recent decades. These are characterised by their excellent stratigraphic depth, diverse and abundant fossil assemblages, and detailed chronologies derived using multiple methods. Here we provide an overview of the major advances generated by studies of these four deposits, and consider how they will continue to help refine our understanding of how species responded to glacial–interglacial cycling and the arrival of humans.

20. KEYNOTE TALK

Settling the West: 50,000 years in a changing land

Joe Dortch, Jane Balme, Jo McDonald, Kate Morse and Peter Veth

Centre for Rock Art Research and Management, School of Social Sciences, The University of Western Australia, Perth WA 6009

Australia was colonised by anatomically modern people more than two thousand human generations ago. Over this vast period, their descendants, including Western Australia's Aboriginal peoples, adapted to diverse environments and glacial-interglacial climatic fluctuations: in tropical savannahs, deserts, woodlands and forests. Within each region, economies became specialised, and there is evidence for genetic differentiation between regions. Through deep time there is also evidence for inter-regional contact and exchange in the realms of religion, language and art, and changes in symbolic communication. These achievements are remarkably well-documented in Western Australia, which features many of the oldest sites in the continent. In this paper we review evidence from the Kimberley, Western Desert, Pilbara and South-West. Each region contains at least one site first occupied more than 45,000 years ago, and numerous other sites first occupied in the Late Pleistocene. We describe the archaeological evidence for the early development of a range of complex modern behaviours from each region, including symbolic behaviour, information exchange, ground stone technology, and ecosystem engineering. We also address the apparent tension between regional continuity and inter-regional contact and exchange.

21. KEYNOTE TALK

Runoff and groundwater responses to climate change in south-west Western Australia

Don McFarlane*, Richard George**, John Ruprecht*, Steve Charles*** and Geoff Hodgson***

* University of Western Australia ** Department of Primary Industries and Regional Development *** CSIRO Floreat Laboratories

Unlike other western coastlines in the 29–38^{o}S latitude zone in the Southern Hemisphere, south-western Australia has a much high rainfall because it has the south-flowing warm Leeuwin Current as well as the north-flowing cold Westralian current. A warming and generally drying climate in south-west Western Australia, most evident since about 1965, has reduced problems caused by too much water reduced water supplies. As well as the size of the climate change, impacts on runoff and groundwater levels are mainly affected by the depth of the regolith, and whether and when native vegetation was cleared.

In the inland Wheatbelt there is 'drying from above and wetting from below' affecting dryland salinity and flooding problems. Saline groundwaters are still rising under cleared land where the regolith is deep, clearing has been more recent and/or the reduction in rainfall hasn't been sufficient to reduce recharge below groundwater discharge levels. The lower rainfall has slowed the rate of salinization and in some cases groundwater levels have fallen. Over time, lags after clearing land with deep regoliths will dissipate and the system will better reflect climate. The reduction in rainfall has greatly reduced runoff and major flooding, even in catchments where the valley floors have expanding salinity. However, major flooding remains an episodic issue, with its incidence now more in summer than in winter, probably reflecting a change from saturation-excess to infiltration-excess processes. This change has implications for flood prediction and mitigation.

In the Zone of Rejuvenated Drainage (which includes the Darling Range), groundwater levels in cleared areas have more closely reached an equilibrium with the drier climate and land and stream salinization risks have reduced. In vegetated areas, mainly in the Darling Range, groundwater levels have started to fall below the valley inverts resulting in substantial reductions in stream runoff into dams. As a result, Perth has going from being almost entirely dependent on runoff into dams for its drinking water, to not having any usable runoff in some years. The native vegetation is still adapting to the warmer and drier climate, and enhanced CO_2. While complicated by forest management practices, some western areas now have greater leaf area indices but are also experiencing tree deaths after the very dry winters such as in 2010.

On the Perth Basin groundwater level under perennial vegetation is falling everywhere as plants use a higher proportion of incoming rainfall. The less intense and more intermittent nature of rainfall is increasing interception losses. Cleared areas with high watertables are least affected because any reduction in recharge may be offset by lower drain flows and evaporation from groundwater-dependent vegetation. This will continue until groundwater levels fall beneath drain inverts and plant rooting depths. Groundwater levels on the Perth Basin are also locally impacted by pumping and land uses, especially urbanisation and afforestation. Streams that arise from inland areas (rather than from within the Perth Basin) traditionally gain fresher water from unconfined aquifers. Falling groundwater levels is starting to change them from gaining to losing streams, reducing surface water yields and increasing the risk of aquifer salinization.

In summary, the hydrology of south-west Western Australia is still adjusting to historical clearing of native vegetation and a drier and hotter climate since about 1965. As well as continuous trends, there are abrupt changes in hydrological processes as groundwater levels approach or receded from valleys in the Wheatbelt and Darling Range. How native vegetation is adjusting to the changed climate is less clear. Climate projections indicate a continuing drying trend with increased temperatures and possibly a greater proportion of rainfall and therefore flood risks in summer. Water yields in dams and aquifers will continue to decline. However, soil waterlogging, winter flooding and dryland salinity risks will probably continue to abate.

22. KEYNOTE TALK

Progressing Western Australian collision with Asia: implications for regional orography, oceanography, climate and marine biota

Myra Keep[1], Ann Holbourn[2], Wolgang Kuhnt[2] and Stephen Gallagher[3]

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[3] School of Earth Sciences, The University of Melbourne, Victoria 3010

The western margin of Australia has migrated over 30° northward in the last fifty million years. As it progressed it carried evidence of greenhouse to icehouse climate and ocean transitions in the sedimentary sequences especially in the offshore region. In the last ten million years Australia has collided with Asian plate to our north leading to the uplift of the Indonesian archipelago and Papua New Guinea highlands blocking oceanographic interchange between the Indian and Pacific Oceans. This created the near "modern" oceanography of the region with the onset of the Indonesian Throughflow and related Leeuwin Current. It also resulted in the ongoing crustal stress in the North West Shelf area causing significant seismicity and faulting. Recent coring by the International Ocean Discovery Program and RV *Sonn*e has yielded superb palaeoclimate and palaeoceanographic archives that will uncover detailed evidence of deep and near recent time evolution of this margin. Knowledge of past ocean and climate of Australia's western margin is essential if we are to interpret and predict the consequences of ocean/climate variability with future climate change. However, over the next few million years progressive future collisional tectonism has the capacity to destroy these fine archives via earthquake activity, landslides, narrowing oceanic transportation routes (disrupting the global thermal circulation), and ultimately destroying these sediments during collision.

23. KEYNOTE TALK

Old climatically-buffered infertile landscapes and seascapes yield new perspectives on Western Australia's biodiversity, Noongar cultural heritage and conservation

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Old climatically-buffered infertile landscapes (Ocbils) and seascapes (Ocbiss) are characterised by geomorphology persistence, usually for tens of millions of years, with an oceanically-buffered climate since globally highest sea levels 90 Ma, and deeply-weathered infertile soils especially low in phosphorus. The ancient Ocbils are found across 12 Global Biodiversity Hotspots, predominantly in the southern hemisphere in regions that escaped Quarternary glaciations, and are especially common in the Southwest Australian Floristic Region (SWAFR) as lateritic, granitic, quartzite or sandplain uplands. Due to the globally-unique Leeuwin Current, the nearshore seascapes of SWWA appear to be the only Ocbis. This review outlines Ocbil theory, first published in 2009, and documents recent trends in relevant research on terrestrial and marine biodiversity, Noongar cultural heritage and conservation.

A comparison of the young often-disturbed fertile landscape (Yodfel) at Downe Bank, Charles Darwin's famous chalk grassland study site in Kent, UK, with the Ocbil at the Shire Cemetery at Gingin, WA, serves to highlight ecological and evolutionary predictions arising from Ocbil theory. Such predictions include the Gondwanan Heritage (reduced extinction rates) and Ultimate Self (long-lived organisms) hypotheses, the James Effect relating to selection for mechanisms that conserve genetic diversity in small disjunct population systems, novel ecophysiological adaptations to soil infertility, and the Reduced Hybridisation hypothesis for Ocbil organisms.

These predictive hypotheses of Ocbil theory are attracting increasing attention locally, nationally and globally (e.g., in Brazil), with rigorous experimentation underway on several fronts. The theory has broadly withstood independent examination, and opened fresh perspectives in disciplines as diverse as restoration ecology, ethnoecology, nutrient ecophysiology, fish biology and fire ecology. Noongar people developed differential lifeways and spiritual beliefs pertaining to Ocbils v/s Yodfels. Emerging cross-cultural collaborative research with Noongar elders demonstrate lasting conservation principles, including the accentuated need to reduce disturbance rates for the SWAFR's Ocbil uplands and Ocbis nearshore reefs and seagrass beds. Contrary to mainstream Yodfel-based theory, a focus of human activities on regularly-disturbed landscapes such as along coastlines and lowland alluvial terraces has much to commend for biodiversity conservation in Ocbil-dominated regions.

24. KEYNOTE TALK

Understanding loss from climate change in everyday places in Western Australia

Petra Tschakert

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In this talk, we aim to advance theory and evidence about social losses arising from climate change. As an interdisciplinary team with expertise in human geography, psychology, ecology, and literacy and gender studies, we examine what people from the Swan Coastal Plain to the Central Wheatbelt value, and how fire, drought and flooding put these values at risk. Through our methodologically innovative approach, we hope to reveal how community members in rural and urban places along a ~400km long transect make value trade-offs and decisions over desirable futures. Our ultimate goal is to enhance capacity among our research partners and ourselves to locate acceptable and intolerable losses, manage grief and hope in familiar places, and reduce harm from climate change, by engaging with people in at-risk places and examining how to live with unavoidable loss. Our collaborative inquiry will promote a resourceful vision, designed by community members, resource managers, and local government and built into adaptation and disaster management policies. Empowering local communities to embrace hope and grief will lower pressure on mental health services and raise quality of life. New scholarly insight from this science of loss offers two significant benefits, namely a critical analysis of community resilience in the face of socio-economic and environmental threats, and inclusive planning for place-based adaptation.

POSTERS FOR COMPETITION: ABSTRACTS

University Club Banquet Hall, UWA

POSTER AWARDS

Best-poster prizes ($1,000 each):

1. Dacian Gold – PESA Award
2. Aurora-Environmental Award
3. Lucy Florence Victoria Hosking Memorial Award
4. Francis Thomas Gregory Memorial Award
5. Curtin University-sponsored Award
6. Edith Cowan University-sponsored Award
7. Murdoch University-sponsored Award
8. The University of Western Australia-sponsored Award
9. Curt Teichert Memorial Award
10. Sir John Forrest Memorial Award

Authors have sole responsibility for the content of their Abstract and poster

1. POSTER FOR COMPETITION

Ammonium toxicity and resistance in canola genotypes

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Ammonium toxicity is one of the most common problems that can decrease plant growth. Most crops have poor resistance to ammonium toxicity, but canola is particularly sensitive. We characterized the differences among canola genotypes in resistance to ammonium toxicity. Two experiments were conducted in the University of Western Australia glasshouses using soil supplemented with nitrification inhibitor dicyandiamide. In the first experiment, eight ammonium chloride treatments and five calcium nitrate treatments were tested using one canola genotype grown for 35 days. In the second experiment, screening of 30 canola genotypes was conducted at selected concentrations of ammonium using nitrate supply as control.

High ammonium application (60 mg N/kg soil) significantly decreased dry weight of shoots and roots of canola and acidified the rhizosphere soil from 5.9 to 5.6. In the second experiment, there was a wide variation among genotypes in sensitivity to high ammonium application, with genotypes Tarcoola-22, SC01-3 and Zy001 having greater shoot dry weights than other genotypes and the highest shoot nitrogen concentration of all genotypes, suggesting the strongest resistance to ammonium toxicity among the tested genotypes. Genotypes SC13-3, Tarcoola-22 and Zy001 had root dry weight up to 35% higher at high soil ammonium compared with the nitrate control. In contrast, genotypes SCO3-1, AV-Opal and Zhongshuang4B showed the largest reduction in shoot weight, and genotypes AV-Opal, Charlton and SCO3-1 showed the largest reduction in root weight at high ammonium application. The residual ammonium in soil at harvest after 35 days of growth was higher in the sensitive than the resistant genotypes, suggesting lower ammonium utilization in the former. The results indicate that it is possible to select genotypes of canola resistant to high ammonium concentrations in soil.

2. POSTER FOR COMPETITION

Petrophysical characterisation of the south-eastern Capricorn Orogen basin lithologies and VMS deposits, WA

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We present the first compilation of available downhole petrophysical information from the base metal deposits hosted within the Capricorn Orogen, and acquisition of new petrophysical data from within the south-eastern Capricorn basins. Typically, petrophysical data is presented within the literature as mean values, however, this is not always useful for understanding the petrophysical variations of a deposit and associated host rocks. We go beyond presenting mean values and provide a presentation of the petrophysical distributions, drawing conclusions from logged lithology and alteration. Limitations exist where geological logging is incomplete, or petrophysical datasets are limited to a single drill hole or petrophysical property.

Resistivity measurements from the Yerrida, Earaheedy, and Collier Basins provide useful measures of the sedimentary basin conductivities. While density measurements at Abra can be used to distinguish host lithologies from ore units. Magnetic susceptibility and resistivity measurements are also useful for discriminating between sulphide mineralisation and unmineralised host rocks at the DeGrussa and Abra deposits. However, new geological interpretations of the DeGrussa host basin suggest the basal formation is an extensive conductive unit; limited measurements from the conductive components within this formation mean this is not evident from the available DeGrussa petrophysics. Overall, this compiled petrophysical information has provided a database useful for directing interpretations of available electrical datasets within the Capricorn Orogen.

3. POSTER FOR COMPETITION

Do juveniles experience more risk? Assessing predation risk in the King's skink (*Egernia kingii*)

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The risk of being predated upon is highly influenced by the ontogenetic stage of the prey species (Bateman & Fleming, 2009; Glaudas *et al.*, 2006). Although dietary studies of predators have typically been used to assess a species risk of predation, realistic soft clay models are a valuable alternative, with predators able to be identified from marks left in the clay (Bateman *et al.*, 2016; Webb & Whiting, 2005). The King's skink, *Egernia kingii*, is a large endemic skink to Western Australia measuring up to 244 mm SVL (Storr, 1978). Despite the fact that it is one of the largest skinks in WA, the King's skink remains relatively unstudied (Arena & Wooller, 2003; Masters & Shine, 2003). Anecdotal reports indicated juveniles may experience higher risk of predation than adults (Aubret *et al.*, 2004; Bonnet *et al.*, 1999), with adults potentially being able to actively defend themselves from certain predators (Masters & Shine, 2003).

In this study we assess the risk of predation for juvenile and adults King's skinks across three isolated islands and a coastal mainland site that vary in predator assemblage. At each of the four sites, 25 sets of Adult (SVL 200mm) and juvenile (SVL 100mm) King's skinks, as well as control balls (diameter 100mm) made from brown modelling clay were deployed between October and November 2017 and checked twice daily for 5 days. Predation events were identified from attack marks left in the clay and differences between model types and sites investigated using general linear mixed models (GLMM's). A significant difference in attack rates between the sites was detected ($P < 0.001$), with Penguin Island experiencing the highest attack numbers, despite the lack of terrestrial predators on the Island. There were however mixed results for attack events for models when compared across and within sites.

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4. POSTER FOR COMPETITION

Acquisition of *Symbiodinium* and bacterial communities in early life stages: source and dynamics

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Microbes are essential in maintaining the health of marine ecosystems. They govern global biogeochemical cycling and form symbioses with a large number of marine invertebrates including corals. Through evolution corals have established mutualistic relationships with a dynamic and highly diverse consortium of microorganisms such as dinoflagellate unicellular algae in the genus *Symbiodinium* (zooxanthellae), bacteria, archaea, viruses and fungi. This complex system has been termed the 'coral holobiont'. In particular, both bacteria and *Symbiodinium* are considered key players in maintaining the coral health status in both the adult and early life history stages. Despite the importance of each, the extent to which the two microbial communities, bacteria and *Symbiodinium*, interact in the maintenance of the coral health status is still unknown. In particular, few studies have examined the source, temporal dynamics and reciprocal influence within microbial communities throughout the early life history stages of coral development.

Here, we explored the coral-associated *Symbiodinium* and bacteria communities across different development stages of the coral species *Acropora digitifera* in Coral Bay, Western Australia. Using high throughput sequencing of the ITS-2 region and 16S rRNA we characterised the *Symbiodinium* and bacteria communities in parents, gametes, larvae, spat and juveniles, as well as the surrounding environment (water and sediment). This project represents the first attempt to characterise baseline patterns of diversity and dynamics of coral-*Symbiodinium*-bacterial communities across coral life history stages.

5. POSTER FOR COMPETITION

Sex on the Rocks: Recruitment Genetics of a Tree Endemic on Granite Outcrops

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In south-west Australia, granite outcrops support hyper-diverse plant communities, some species of which persist as small, genetically insular populations for extremely long periods. Due to the fire-sensitivity and conservation status of some granite endemics, experimental burns are inappropriate. Thus, opportunities to study the impact of fire on plant population genetics seldom arise. Following a wildfire in a stand of the granite-endemic, lignotuberous tree *Eucalyptus caesia* at Boyagin Reserve, we surveyed genetic diversity, growth and survival, and parentage of seedlings. The entire adult stand (n = 180) plus all seedlings located (n = 115) were genotyped with 15 microsatellite loci. There was low heterozygosity and high fixation in seedlings compared to adults. Seedling mortality was high, with 32 seedlings still alive two years after the fire. Our data did not support expectations of post-germination selection against homozygous progeny. Based on height measurements, seedlings resulting from self-pollination (n = 19) could not be distinguished from outcrossed seedlings (n = 69). Whether these results can be explained by variability in seedling microsites, or purging of deleterious alleles, requires further investigation. Parentage analysis revealed limited seed dispersal (14.6 ± 3.8 m). By comparison, pollen movement was more extensive (67.8 ± 9.4 m), yet still restricted within the stand. Genetic mixing through wide pollen dispersal within stands, and extreme longevity of adults via lignotuber resprouting could retard extirpation in *E. caesia*. However, poor understanding of recruitment over the long-term, and lack of population age-structure data, represents a significant challenge to appropriate conservation management.

6. POSTER FOR COMPETITION

Assessing relictual status via alpha and beta diversity

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Reedia spathacea F.Muell is a declared rare species of sedge (Cyperaceae) found in the peat swamps of the Jarrah Forest and Warren Biogeographical Regions. *Reedia* has been identified as a Gondwanan relict species on the basis of (relatively little) morphological and genetic evidence. Characteristics of relictual taxa in the south-west include being of Gondwanan or Pangaean origin, thus having become restricted to mesic habitat from a previously wider distribution and retaining some ancestral morphological states. They also are expected to have high beta genetic diversity with relatively low alpha diversity and be phylogenetically distinct from sister taxa. Exploration of these criteria through microsatellite analyses will be presented. If this study supports the recognition of *Reedia* as a highly-restricted relict then the genetic consequences of historical population decline or extinction can be addressed. In a broader sense, our understanding of organisms that have become rare will be improved, in turn bettering our understanding of the pressures that have caused contraction in ranges historically, and helping us to predict future trends in the face of a rapidly changing climate

7. POSTER FOR COMPETITION

Sea-level controls on buried geomorphology within the Swan River Estuary during the Late Quaternary

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A high-resolution seismic survey was carried out across the metropolitan reach of the Swan River (Perth, Western Australia) to investigate the sub-surficial geomorphology of this wave-dominated estuary. Shallow-imaging data, integrated with sediment cores and LiDAR images, revealed a complex system of buried palaeochannels, which developed during glacial sea-level lowstands, and related channel-fill deposits that formed during interglacial highstands.

Four major acoustic reflectors (seafloor-R1-R2-R3) were found bounding as many seismic units (U1-U2-U3), over the bedrock.

The deepest unit (U3, between R2 and R3) has been interpreted as the Perth Formation, which consists of ~20m thick fluvial to estuarine sediments, deposited during the Last Interglacial (~130-80 thousand years Before Present, BP) and infilling a palaeo-valley that cut the bedrock.

U3 is overlaid by a ~27m thick unit (U2, between R1 and R2), composed of heterogenic fluvial (possibly lacustrine) and estuarine deposits. This sedimentary sequence belongs to the Swan River Formation and mainly infills a palaeochannel that incised the older formations during the Last Glacial lowstand (about 18,000 years BP).

The shallowest unit (U1, between river-bed and R1) is up to 14m thick and comprises Holocene fluvial and estuarine sediments (last 10,000 years). These sediments are found filling palaeochannels and blanketing the pre-existing topography.

This research represented the first environmental high-resolution acoustic investigation of the Swan River estuary and improved the understanding of its Late Quaternary development, providing a useful tool for modelling the river onset and evolution, following sea-level transgressions.

8. POSTER FOR COMPETITION

Characterizing microbial communities in subsurface petroleum environments of Western Australia and beyond

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Crude oil and natural gas reserves in subsurface environments are often residence to anaerobic microbial communities that degrade and consume petroleum compounds for their metabolic activities. In the petroleum-rich North West Shelf (NWS) of WA, large amounts of crude oil are biodegraded, which decreases extraction and purification efficiency. In shale gas formations, such as the Antrim Shale in the Michigan Basin, sizable depletions of natural gas are likely due to methanotrophic microbial communities. While there is significant geochemical data pertaining to petroleum biodegradation, considerably less data has been published on microbial ecology in subsurface petroleum environments. By characterizing the genomic diversity and metabolic functions of microbial communities residing in subsurface petroleum reserves, microbial metabolism can ostensibly be utilized for more efficient extraction of residual crude oil or production of extractable natural gas. Microbial community characterization will be carried out through metagenomic analysis, and will be coupled with biomarker and compound-specific isotope analyses to ascertain biodegradation mechanics and pathways. Anaerobic incubation experiments will be carried out to test for different substrate and nutrient controls on microbial petroleum degradation. This project aims to expand on microbial ecology data within the deep biosphere, especially for subsurface energy reserves affected by microbial activity.

9. POSTER FOR COMPETITION

Coral core Sr/Ca and Li/Mg records from the northwest shelf of Australia: evidence for widespread coral bleaching impacts during 2010/11 and 2012/13 marine heat waves

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The ability of corals to document their past exposure to, and the impacts of ocean warming events could greatly assist with our understanding of the effects of climate change on reef environments. For this study, we examined trace element and extension signatures associated with recent widespread ocean warming events (summers of 2010/11 and 2012/13) in seven coral core records (*Porites* sp.) collected from a variety of different reef environments on the NW shelf of Australia. Acute increases in Sr/Ca and Li/Mg ratios and/or declines in linear extension were observed in most to all of the records corresponding with the timing of these two events. In particular, the increased incidence of anomalies in the records for the 2012/13 event was consistent with modelled thermal stresses which showed much higher values across the region compared to the earlier 2010/11 event. However, no significant relationships between thermal stress and the magnitude of geochemical or extension anomalies were observed between the different records. This suggested that local environmental differences and variable acclimation influenced the response of the corals to the two warming events. Lastly, the strong coupling observed between Sr/Ca and Li/Mg anomalies contradicted existing theories that sought to explain the formation of acute geochemical anomalies in core records. We thus provide new evidence to suggest their formation is related to the increased attenuation of the seasonality of trace element ratios due to infilling of coral skeleton over narrower growth intervals.

10. POSTER FOR COMPETITION

Pore pressure in sediments off the Sumatra accretionary margin

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A recent International Ocean Discovery Program (IODP) expedition, 362, sampled sediments approximately 225 km seaward of the deformation front of the Sumatran Subduction Zone. Core sampling during this expedition has shown a sequence of siliciclastic sediment interpreted as Nicobar Fan, with high sedimentation rates of > 100 m/Myr. A 17m thick section of tuffaceous silty claystone near the base of the sequence exhibits anonymously high porosity relative to the overlying sediments and inferred compaction trend. This section of high porosity is associated with a high amplitude negative polarity seismic reflector discovered by former seismic surveys and has been identified to be a smectite rich alteration product from the volcanics. Pore pressure estimates based on porosity proxies and using the equivalent depth method, indicate hydrostatic pressures down to the HANP related clays, with a HANP clay exhibiting a most likely case of mild over pressure of 1.15 SG. Mild overpressures are attributed primarily to disequilibrium compaction resulting from the rapid sedimentation of the 'overburden'. This may have implications for proto-decollement formation and the effective stress profile once these sediments reach the deformation front and form part of the accretionary wedge. The combination of mild overpressures with sediment strengthening and further overpressure mechanisms such as smectite-illite alteration switching on further down the deformation front may explain the unusual and extensive up-dip propagation of faults along the Sumatra subduction zone.

11. POSTER FOR COMPETITION

How do animals respond to mine site restoration?

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Globally increasing rates of mine site discontinuations are resulting in the need for immediate implementation of effective biodiversity and conservation management strategies. Over 60 000 mines across Australia have been identified as discontinued, yet despite restoration being a legislative requirement, the number of these sites confirmed as restored and officially closed is extremely low. Monitoring vegetation structure and condition is a common method of assessing restoration success, however monitoring animal responses is relatively uncommon. Animals are generally assumed to return to pre-disturbance abundances following the return of vegetation (Field of Dreams hypothesis; 'build it and they will come'). In practice, recovering animal biodiversity and community structure can be some of the most difficult components to achieve and asses following the restoration of degraded sites.

We assessed fauna recolonisation and responses to mine site restoration at a Mid-West Western Australian mine. Numbers of animal detections significantly increased with increasing distance from the active mine pit, regardless of whether the site was a restoration or reference site. Restored sites were of the same age, however both species diversity and abundances were significantly higher in the site farthest from active mining activities. Feral species (cats, wild dogs, and rabbits) were detected across all sites, but large, native predatory animals such as *Varanus* species were detected almost exclusively at the reference and restoration sites farthest from the active mine pit.

12. POSTER FOR COMPETITION

Mapping Indigenous Ecological Knowledge of Sea Country

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In regions where the majority of land is under Indigenous ownership or where Indigenous people retain a connection to their marine estates, respect for and an ability to include the rich knowledge base of Indigenous people in environmental research is essential. Particularly for marine management, drawing together the knowledge of Indigenous communities and marine scientists can result in improved data quality. Maps of benthic habitats are considered some of the best surrogates for biodiversity in the marine environment and are an essential foundation for effective management planning. Indigenous ecological knowledge (IEK) can be an excellent source of information for mapping the marine environment. This contribution is especially valuable when other data is scarce. This study developed a methodology which combines elements of expert elicitation and participatory mapping techniques to assemble the IEK of the Anindilyakwa people of the Groote Eylandt Archipelago off Australia's poorly surveyed Northern coast. Representatives from 14 Anindilyakwa clan groups participated (n=40), resulting in 21 individual maps. Nine broad-scale habitat classifications, predominately in the intertidal and nearshore marine environment, were described in both Anindilyakwa and English. The information gathered was then used to develop benthic habitat maps covering a combined area of ~1800km^2, identify conservation priority areas and ascertain distributions of vulnerable species. The methodology developed provides a cost effective and replicable technique to characterise large areas of the marine environment from IEK and facilitates ongoing information exchange and respectful knowledge sharing between western scientists and Indigenous communities.

13. POSTER FOR COMPETITION

Syn-rift sequence development in a tide-dominated, fault-bounded embayment

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Stratigraphic patterns and sequence development in tectonically active extensional basins remain poorly documented in comparison with passive-margin settings. The Early Permian Irwin River Coal Measures in the Northern Perth Basin (Western Australia) record a complex stratigraphic arrangement of conglomerate, sandstone, mudstone, and coal, and have been attributed to delta plain depositional environments that developed in a cool–temperate climatic setting during syn-rift activity. Sedimentary analysis of outcrop and core data from the fault-bounded Irwin Terrace is used to distinguish nine facies associations reflecting deposition in braided rivers, fixed-anastomosing channel belts, tide-influenced coastal environments, and storm-affected distal bays. The broader depositional system is interpreted as a morphologically asymmetric tide-dominated embayment with a fluvial and wave influence developed in a basin margin setting.

Extensional faulting at the onset of deposition created the slope necessary for the inception of gravelly braided channel systems during an underfilled phase. It was succeeded by a period a coastal plain aggradation during which sediment supply kept pace with tectonic subsidence. Subsequent backstepping and drowning phases were characterised by retrogradational stacking pattern suggesting the progressive flooding of marginal-marine areas that were later overlain by more distal marine elements. It is proposed that the preservation of a shallow-marine syn-rift succession was made possible by the geomorphological confinement of the embayed system hampering transgressive ravinement and increasing tidal resonance. High-frequency stratigraphic cycles of autogenic origin were recorded by channel incision, infill, and abandonment, and may contain 'transgressive' or 'regressive' coals associated with base-level rise and fall. On the non-deltaic shoreline, beach-like sandflats prograded into a muddy central basin. The superposition of high-frequency sequences may record major phases of delta lobe expansion or abandonment. Tidal and wave ravinement surfaces are recognised at the base of backstepping subtidal bars and storm-generated beds, respectively. The proposed syn-rift sequence model recording the initiation and filling of a low energy embayment on an active rift basin margin may be applied in similar tectonic and/or depositional contexts worldwide.

14. POSTER FOR COMPETITION

Is blue really better? The success of coloured pan traps for sampling insects in the city of Perth

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Urbanisation leads to habitat loss, which can reduce the abundance and diversity of plants and animals in cities. Pollination is critical for the reproduction of many flowering plant species, and flower-visiting insects are the most common agents of pollination. Pollinating insects are diverse and are likely to have different responses to urbanisation i.e., they may decline, prosper, or may not be affected. This study investigates how the insect population has responded to urbanisation across the city of Perth, and specifically, which habitat characteristics are important for pollinating insects. We used yellow and blue pan traps to measure the relative abundance and richness of flower-visiting insects. We determined whether insects favour particular trap colours because such a preference would influence our interpretation of the data. Previous research suggests that Hymenoptera prefer blue traps, however other studies found that yellow is preferred, or that there is no consistent colour preference. We trapped insects in nine reserves and 32 gardens across Perth, from September–December in 2016 and 2017. Reserve and garden characteristics were measured in the field and using GIS. Regression analyses were used to determine which characteristics predicted insect abundance and richness. We found that Coleoptera almost exclusively selected blue traps, while Diptera were usually observed in yellow traps. Overall, Hymenopterans did not exhibit an obvious colour preference, however, certain genera did favour blue traps. Preliminary investigations suggest that site and landscape characteristics do not have a significant impact on the total number or richness of flower-visiting insects. The lack of strong positive associations between site and landscape matrix characteristics (e.g. flower number, site size, distance to nearest remnant) indicates that the chosen study sites may provide ample habitat and resources to support assemblages of flower-visiting insects.

15. POSTER FOR COMPETITION

Soil nutrient dynamics in response to urbanisation on the Swan coastal plain

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Urbanisation and consequent destruction and fragmentation of natural areas are one of the most significant threats to biodiversity worldwide. Urbanisation coupled with the impacts of nutrient enrichment may further amplify biodiversity loss, especially in nutrient-poor landscapes such as south-west Western Australia. Further to this, it is currently unclear whether differing fragmentation contexts and land use changes consistent with urbanisation, influence nutrient enrichment. Taking advantage of a historical dataset, this study quantifies the change in soil chemistry over a 25 year period during which the population of the greater Perth region grew by 65% and by approximately 43% in urbanised extent. Analyses here are restricted to formerly widespread and now threatened banksia woodlands, a vegetation type renowned for its exceptional plant biodiversity.

Historical (1991–1993) sampling by Gibson *et al.* (1994) was compared to contemporary sampling (2015–2017) at the same locations. Following original protocols, 20 subsamples were taken from the top 10 cm of the soil profile from 153, 100 m^2 plots across the swan coastal plain (Western Australia), excluding leaf litter. Moisture content was removed by drying samples in an oven at 50°C until constant mass was achieved; subsamples were then combined and sieved to 2 mm. A minimum 500 g sample was taken for laboratory analysis. The analysis was conducted by ChemCentre, Perth Western Australia at both time periods, for the following soil properties: pH, EC, Total N, Total P and exchangeable cations (Ca, Mg, Na, K, Mn, Al). Results from these were used in combination with urbanisation metrics, including fragment size, distance of plot from fragment edge, distance to nearest fragment and the proportion of the surrounding landscape that is remnant bushland.

Preliminary analysis using a subset of data from 80 contemporary and 72 historical plots currently do not suggest any apparent relationships with the parameters tested. Full results from re-sampling nutrient concentrations over a 25 year period could be useful in identifying trends in soil–landscape–vegetation interactions. We have evaluated preliminary results of potential drivers of nutrient change related to urbanisation in a nutrient-poor landscape. Currently, these do not suggest enrichment is following any particular pattern in response to urbanisation. Presented results will be able to provide comprehensive conclusions regarding these interactions.

16. POSTER FOR COMPETITION

Reading Plants

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Plant motifs in rock art represent a tangible connection to past plant-based lifeways and practices. They are seldom found in the world's rock art assemblages, and yet they appear in unprecedented amounts across the Kimberley region of Western Australia. Unparalleled botanical representations can be found within each traditional stylistic period, from simple grass prints to intricate depictions of yams and bush plums. The plants themselves are represented stylistically and representationally, as isolated motifs and integrated into extensive, complex panels with deeply symbolic anthropomorph-plant figures known as Florianthropes. As a total record of plant-based rock art, the Kimberley presents a unique chance for archaeologists to gain a deeper understanding of past plant-based cultural practices, such as eco-scaping, in a global artistic and archaeological record inherently biased towards animals and lithics. Kimberley rock art subverts the common assumption of Australian Indigenous populations as traditionally lacking agricultural behaviours; it in fact demonstrates a deep cultural understanding of the natural world dating back thousands of years. This poster serves to educate the wider archaeological community on the prevalence of plant motifs in Kimberley rock art, and their potential as representatives of past cultural plant-based practices.

17. POSTER FOR COMPETITION

Combining approaches to identify biodiversity hotspots in Western Australia

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Recognition of plant diversity hotspots is of great value for conservation planning and helps gain public support for conservation initiatives. The entire Southwest Australian Floristic Region (SWAFR) is an internationally recognised plant biodiversity hotspot. However, in Western Australia additional hotspots have been designated at overlapping spatial scales without using consistent criteria. Areas are recognised as sub-regional hotspots (by the commonwealth) include the Stirling Ranges, northern sandplains, Fitzgerald River bioregion and Mitchell Plateau. However, we are aware of other areas of similar conservation significance, both inside and outside the SWAFR, that are not currently recognised as hotspots. Thus updated mapping of all areas of exceptionally high biodiversity using reliable and reproducible processes is required to guide conservation efforts.

Hotspots are defined by exceptionally high diversity, endemism and evolutionary importance, so plant surveys and specimen records are required to identify them. We employed four different approaches to identify hotspots and provide case study for each method. These are bioregional studies, diversity mapping, phylogenetic mapping and species area relationships.

Most hotpots occur in areas where complex landform, soils and hydrology support diverse habitats. They are also areas with high rates of speciation and/or survival of plant taxa and have functioned as refugia from climate change. Continuing advances in biological surveys, plant taxonomy and assessments of plant diversity, especially in areas threatened by mining have revealed several new hotspot areas. These include parts of the interzone at the eastern boundary of the SWAFR and south of Perth along the Whicher Scarp, Cape Arid /Nuytsland on the southeast margins of the SWAFR and the paleodrainage areas of the Kimberley and adjacent desert. These data also suggest that some rather broadly based hotspots such as the Wheatbelt, Pilbara and Geraldton Sandplains could be more finely divided.

Species area relationships can help to define diversity hotspots by revealing areas with higher than expected species richness and endemism. Analysis of species occurrence data can also identify areas with high values using diversity metrics such as species endemism, richness or turnover to help identify areas potentially of priority for conservation. This approach is becoming more powerful due to specialised software and models that efficiently define areas where diversity is high, as well as very large accessible species databases. We also acknowledge problems with identifying hotspots due to the limitations of existing data resources, changing taxonomy, spatial uncertainty of records, poor sampling in remote areas and the large scale of analyses. Additionally, while these methods can identify spatial regions of importance our understanding of the processes that define them will require additional phylogenetic, evolutionary, paleobotanical and paleoclimatic studies.

18. POSTER FOR COMPETITION

Measuring hotspot motion in the mantle: A case study from Eastern Australia

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The movement or fixity of hotspots in the mantle has been a source of debate ever since early plate circuit models were unable to reconcile tracks of Pacific Hotspots with those in the Indo-Atlantic realms. Uncertainties in relative plate motions were also argued to be the cause of the discrepancy, so many early workers continued to support a fixed hotspot reference frame within their models. Constraints on plate motion have improved in resolution since, but relative motion between Indo-Atlantic and Pacific hotspots persists in recent models. Hotspot motion in the mantle is, in principle, also detectable using paleomagnetic methods, as the magnetic field of the Earth is global in extent, and sensitive to paleogeographic changes in latitude. Consequently, North-South hotspot movement should be observed as a systematic change in paleomagnetic inclination with time. Attempts have been made to measure the movement of the Hawaiian, and Kerguelen oceanic hotspots using paleomagnetism, but limitations of deep ocean drill core have fuelled debate of the validity of these results. For example, the Kerguelen hotspot appears mostly stationary according to paleomagnetic data. In contrast, some southward motion of the Hawaiian-Emperor hotspot is indicated by paleomagnetic data, although this has been argued to be the result of true polar wander. We decided to evaluate the extent that predicted hotspot motion could be measured using paleomagnetic methods on land, by examining Earth's longest continental hotspot track, the Cosgrove Track in eastern Australia. It is ideal for this study as its present day position in the mantle is known, the track is aligned N-S, and the hotspot was active from at least 9 to 34 Ma during an interval of apparently minimal true polar wander. We present new paleomagnetic results for Australia from Miocene leucitite lavas in New South Wales, and several Oligocene volcanoes in central Queensland (Buckland, Springsure, Peak Range, Nebo and Hillsborough Volcanoes), and with these new results we reconstruct the motion of the Cosgrove hotspot, and other hotspots beneath the Australian Plate. We evaluate the extent that hotspots beneath Australia may have moved in the mantle during the past 34 Ma, present an updated apparent polar wander path for Australia during the Cenozoic incorporating our new measurements, and describe the degree of paleosecular variation of the magnetic field over this interval.

19. POSTER FOR COMPETITION

Basement inheritance controls on Neogene reactivation in the Caswell Sub-basin, North West Shelf of Australia

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Faults in the Caswell Sub-basin show a complex tectonic history including multiple stages of extension and reactivation, as the basin evolved from an interior rift basin during the Paleozoic break up of Gondwana, to an oblique Neogene collisional front between NW Australia and the Banda Arc. A regional study including interpretation of 12,500 km^2 of 3D seismic data and associated regional 2D data, as well as fault population analyses has identified two main tectonically active periods: Paleozoic-Permian- Triassic (3-7 seconds TWT) and mid-Miocene and Pliocene (2–0.5seconds TWT). Paleozoic 3D surface layers show a series of 10–15 km wide half grabens in the Permian–Triassic stratigraphy, with faults truncating at both the Jurassic and Cretaceous horizons, separated from the overlying Neogene faults by Cretaceous shales. Spatial mapping of 3D surface layers and juxtaposition of fault geomorphologies show that Neogene faults locus vertically up-dip of reactivated Paleozoic faults, but have a different strike, dip and morphology, consistent with oblique extension. Fault geometries of both early (Permo–Triassic) and late (Miocene, Pliocene) fault populations indicate that oblique reactivation dominated both episodes, with significant strike-parallel components evident. These results suggests that Miocene–Pliocene deformation is controlled by the underlying Palaeozoic fault architecture, in particular causing re-nucleated, soft-linked Neogene faults consistent with dextral-oblique Neogene slip of the underlying Permo-Jurassic basement. In the Caswell Sub-basin the relationship between reactivated basement faults and Neogene faults has not previously been investigated, and our results show new insights into intracontinental fault reactivation regimes. Understanding fault reactivation styles and strain partitioning assists in hydrocarbon exploration in a region dominated by structural petroleum plays, and constrains the timing of major regional tectonic events.

20. POSTER FOR COMPETITION

Seedling xylem anatomy of two *Banksia* species relative to availability of groundwater

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Fluctuating environmental conditions place plants at risk if they cannot adapt, particularly to warmer temperatures and drier environments. Plants are known to modify their morphology, physiology and anatomy to thrive under these conditions, and xylem anatomy and hydraulic architecture are common traits studied to understand plant adaptations and responses to changeable water availability. However, little is known about the changes to the hydraulic architecture of groundwater dependent plants during their early establishment in water-limited environments. To identify these changes, seedlings of two *Banksia* species were exposed to contrasting groundwater availability treatments in a glasshouse experiment, and tissue sections prepared from stem and root samples. Xylem vessel characteristics (average vessel diameter (D), max diameter (D_{MAX}), average vessel density (VD) and vessel length (V_{L})) were analysed using ImageJ software.

Analysis of vessel characteristics identified significant vascular tapering in both *Banksia attenuata and B. littoralis*, i.e. a low density of large diameter vessels found in roots, and a higher density of small diameter vessels found in the stem. Vessel characteristics of seedlings with access to groundwater did not differ significantly to those with access to only unsaturated soil. This was surprising as studies have shown variation in xylem anatomy of plants exposed to contrasting water availabilities, commonly referred to as the hydraulic efficiency and safety trade-off theory. However, the characteristics did vary between the two species, with significantly larger mean D and D_{MAX} in *B. attenuata* seedling roots, and significantly higher mean VD in *B. littoralis* seedling roots. V_L also differed, with *B. attenuata* having significantly longer vessels than *B. littoralis*. These differences may relate to the contrasting habitat requirements of the chosen species. *B. attenuata* occurs across varying gradients in depth to groundwater, whilst *B. littoralis* is found in low-lying swamp areas. This could suggest that *B. attenuata* may be more 'flexible' in its xylem development, whereas *B. littoralis* may develop a safer anatomy in case of disconnection from groundwater. The findings from this study will be used in an attempt to gain a better insight into how groundwater dependent species' xylem anatomy varies in relation to groundwater availability, and how and why species of the same genus may develop significantly different vessel characteristics.

21. POSTER FOR COMPETITION

Can hydrodynamic processes explain the absence of Western Rock Lobster (*Panulirus cygnus*) in an area of pristine habitat?

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The western rock lobster (*Panulirus cygnus*), is endemic to Western Australia and the basis of Australia's most valuable wild-caught commercial fishery. An important metric used by fisheries scientists to monitor the health of this resource is the abundance of post-larvae (puerulus) that recruit each year (de Lestang et al. 2016). The abundance is a reliable predictor of the catch for the fishery 3-4 years later (Caputi et al. 1995). South of Port Denison, Cliff Head, is an area shown to have lower than expected puerulus settlement in comparison to the surrounding areas of high settlement. This study investigates whether water movements could explain the cause of this inconsistency.

After hatching, rock lobster phyllosoma larvae spend up to 11 months in offshore waters. As ocean currents transport phyllosoma to the coast, they change to puerulus, capable of swimming at speeds of 0.5 m/s that allows for settlement on inshore reefs (de Lestang et al. 2016). The strength of the currents and temperature has previously been shown to influence puerulus settlement (de Lestang & Caputi 2015). Years that have typically experienced high lobster catches have occurred 3-4 years after higher settlement events, the latter of which have been attributed to a stronger Leeuwin Current. This relationship has been challenged subsequent to the low recruitment years, 2008 - 2009, where the Leeuwin Current was strong suggesting other environmental factors, such as cross-shelf fluxes, could be influence settlement (de Lestang et al. 2015). A hydrodynamic ocean hindcast model for Australia, OzROMS, provides hydrodynamic data for a 15-year period from 2000, allowing for the calculation of monthly alongshore and cross-shelf water fluxes (Wijeratne et al. 2018). Assessment of these fluxes along latitudinal bands indicates that there was low cross-shelf transport at Cliff Head in comparison to other latitude including a low eddy activity from the Leeuwin Current.

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22. POSTER FOR COMPETITION

A qPCR assay for the detection of *Phytophthora cinnamomi* including an mRNA protocol designed to establish propagule viability in environmental samples.

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Phytophthora cinnamomi is the cause of root and collar rot in many plant species within natural ecosystems and in horticulture worldwide. A species-specific primer and probe were designed based on a mitochondrial locus encoding subunit 2 of cytochrome c oxidase (Cox2). Eight PCR primers, including three forward and five reverse, were designed and tested in all possible fifteen combinations. Annealing temperatures were optimized for each primer pair set to maximize both specificity and sensitivity. Each set was tested against *P. cinnamomi* and some closely related species from within clade 7, *P. parvispora* and *P. niederhauserii*. From these tests five primer pairs were selected based on specificity, and with a species-specific *P. cinnamomi* probe, used to develop qPCR assays. The specificity of the two most sensitive qPCR assays was confirmed using the genomic DNA of 29 *Phytophthora* isolates, including 17 isolates from 11 species from clade 7, along with isolates of a representative species from each of the remaining 9 clades. The assay showed no cross-reaction with other *Phytophthora* species, except for *P. parvispora* which showed late amplification at high DNA concentrations, and was able to detect as little as 150 ag/µl of *P. cinnamomi* DNA. The efficiency of the qPCR protocol was evaluated with environmental samples (soil, plant roots) artificially inoculated with *P. cinnamomi* plugs. *Phytophthora cinnamomi* was detected in all samples with a sensitivity of 1.5 pg/µl. DNA from dead organisms may persist in soils very much longer than RNA, and a positive result from a DNA extraction is not proof of the presence of a living organism. A protocol was developed for the extraction of RNA from environmental samples, and following cDNA synthesis, the qPCR assay was then used to confirm the presence of living propagules.

23. POSTER FOR COMPETITION

Laying Cables; Redressing Sulphide Oxidation in Seagrass Rhizospheres

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Seagrasses thrive in anoxic sediments where sulphide can accumulate to phytotoxic levels. So how do seagrasses persist in this environment? Here, we propose that oxygen loss from actively growing root tips protects seagrasses from sulphide intrusion not only by abiotically oxidising sulphides in the rhizosphere of young growing roots, but also by manipulating the abundance of sulphate-reducing and sulphide-oxidising bacteria. We used a novel multifaceted approach combining imaging techniques (confocal fluorescence *in situ* hybridisation, oxygen planar optodes and sulphide diffusive gradients in thin films) with microbial community profiling to build a complete picture of the micro-environment of growing roots of the seagrasses *Halophila ovalis* and *Zostera mucronata.* Oxygen loss was restricted to actively growing root tips, indicating that, on the meadow-scale, seagrasses will have limited ability to promote sulphide oxidation. On the micro-scale, however, oxygen leakage corresponded with decreased abundance of potential sulphate-reducing bacteria and decreased sulphide concentrations in the rhizosphere surrounding growing roots. Furthermore, roots leaking oxygen had a higher abundance of sulphide-oxidising cable bacteria within the root hair zone; which is the first report of these bacteria in seagrass rhizospheres. Thus, oxygen leakage can enhance both abiotic and bacterial sulphide oxidation and restrict bacterial sulphide production around young vulnerable roots, thereby helping seagrasses to colonise sulphide rich anoxic sediments.

24. POSTER FOR COMPETITION

Trait surrogacy and trade-offs in space, time and resources

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Conservation biology promotes retention of biodiversity by managing threatening processes. Invertebrates are the largest contributors to biodiversity, but current taxonomic impediments inhibit their protection. Further, taxonomy can only superficially relate clades for conservation purposes. Therefore, we suggest an alternative trait-based approach to facilitate conservation of rare, cryptic, difficult to survey, or unknown taxa. Here, 'trait surrogacy' is defined as '*the use of a species to surrogate specified traits demonstrating a collective response in other taxa sharing such traits*.' We employ taxa representing a wide array of clades and niches to demonstrate how these factors influence functional traits. We show that categories of traits relating to mobility, reproductive output and specialisation are more useful than taxonomic approaches when considering surrogates in conservation management. Using mygalomorph spiders as trait surrogates for short-range endemics in urban areas, we illustrate how local trait-based approaches can be applied globally. When considering functional traits we argue for the importance of contextualising taxa within the limitations imposed by space, time and resources.

25. POSTER FOR COMPETITION

Paleoenvironmental and paleohydrological records from groundwater dolocrete within a saline wetland in the semi-arid Pilbara region of northwest Australia

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Extensive chemical deposits dominated by dolomite occur within the Fortescue Marsh, a 1000 km^2 wetland in the semi-arid inland Pilbara region of northwest Australia. Given, dolomite precipitation is strongly controlled by reaction kinetics and is inhibited at surface temperatures and pressures, the presence of dolomite indicates specific hydrochemical conditions occurred to overcome kinetic barriers to precipitation, associated with elevated Mg/Ca, salinity and alkalinity. We analysed the geochemistry and stable isotopic compositions of carbonates and groundwater from various depths and locations across the Marsh to reconstruct the hydrochemical conditions involved in dolomite formation and provide paleoenvironmental and paleohydrological records for the Quaternary period. Two major phases of groundwater dolocrete formation are apparent from the presence of two distinct units, based on differences in depth, $\delta^{18}O$ values and mineral composition. Group 1 (G1) occurs at 20-65 m depth and contains stoichiometric dolomite with $\delta^{18}O$ values of -4.02 to 0.71 ‰. Group 2 (G2) is shallower (0-23 m depth) and contains Ca-rich dolomite +/- secondary calcite with a comparatively lower range of $\delta^{18}O$ values (-7.74 to -6.03 ‰). Modelled $\delta^{18}O$ values of paleogroundwater from which G1 dolomite precipitated indicated highly saline source water, which had similar $\delta^{18}O$ values to relatively old brine groundwater within the Marsh, developed under a different hydroclimatic regime. The higher $\delta^{18}O$ values suggest highly evaporitic conditions occurred at the Marsh, which may have been a playa lake to saline mud flat environment. The younger G2 dolomite precipitated from comparatively fresher water, and modelled $\delta^{18}O$ values suggested formation from mixing between inflowing fresher groundwater with saline-brine groundwater within the Marsh. In contrast to the modern hydrology of the Marsh, which is surface water dependent and driven by a flood and drought regime, past conditions conducive to dolomite precipitation suggest a groundwater dependent system, where shallow groundwaters were influenced by intensive evaporation.

26. POSTER FOR COMPETITION

Breakdown and aquatic invertebrate dynamics of single- and mixed-species leaf packs of three native species in the Warren River, south-west Australia

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Forested stream ecosystems derive much of their energy from the breakdown of leaf litter that enters streams. Macro-invertebrates are essential to the breakdown and processing of this leaf litter. Diversity of macro-invertebrates and leaf litter breakdown rates are controlled, in part, by the availability and diversity of food sources. Hence, leaf-packs composed of mixed-species will promote greater macro-invert diversity and enhance breakdown rates than leaf packs composed of single-species. However, the majority of studies of breakdown rates of native leaves in Australian streams have been done on single-species packs. As most litter accumulates as mixed-species packs, it is imperative that we assess litter breakdown rates in the context of multi-species packs. Therefore, we tested the hypotheses that mixed-species packs would (1) enhance invertebrate diversity and (2) accelerate species-specific mass loss compared to single-species packs in the Warren River, a south-west Australian stream. We compared three native species: karri (*Eucalyptus diversicolor*), jarrah (*E. marginata*) and peppermint (*Agonis flexuosa*). Results and implications will be discussed.

27. POSTER FOR COMPETITION

WA Landscape Microbiota

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Western Australia is a well-known biodiversity hotspot, but anthropogenic disturbance, such as agricultural, mining and urban development practices have caused damage to some of our most ancient landscapes, often polluting and/or disturbing such ecosystems. Therefore, restoration practises are, and will be, of pivotal importance to maintain and restore WA landscapes.

Microbes play a vital role in maintaining ecological balance within the environment. Despite this, we know very little about them. In terms of understanding their diversity, patterns of distribution and functions, we've barely scratched the surface. Compared to our understanding of the genetics of everything we see above the ground, microbes, until now, have remained something of a mystery, hidden in the soil. MicroBlitz is a citizen science project where crowd-sourced science is building a state-wide map detailing the biodiversity and health of our environment using DNA sequencing to identify the biodiversity of microbes in WA soils. Together, we are creating a baseline map, a point of reference that can be shared and used to monitor, manage and protect WA's precious environment into the future.

Here, we present preliminary results of our findings, focusing on differential biogeographical patterns across microorganisms, as well as general trends of diversity and evenness across different land uses. We finally compare broadly-used bioinformatic pipelines with new, high-resolution algorithms to resolve the true microbial diversity of WA soils.

28. POSTER FOR COMPETITION

Enhancement of seed germination of wild plant species through priming

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Statement of the Problem: Globally there has been a significant decline in natural habits in arid regions. Desertification is common in arid zones and is a serious problem affecting the survival of many plants endemic to these regions. Revegetation of arid and semi-arid land is difficult because it is widely influenced by extreme climatic factors, disturbance patterns, limited revegetation technology and importantly a lack of understanding of the biology and ecology of native plant species. Seeds are central to the revegetation of degraded lands, but poor seedling establishment limits our capacity to restore diverse plant communities. Priming is an effective method to enhance seed germination in arid and semi-arid regions. The purpose of this study is to enhance seed germination of species endemic to arid regions using priming technology to synchronize germination and hence assist in arid land restoration.

Methodology: A seed priming experiment was conducted on two native plant species (Poaceae) from the Pilbara region (northern Western Australia) in an attempt to improve germination speed, germination percentage and the seeds resistance to water stress.

Findings: Combinations of priming treatments significantly increased germination percentage in both species (*Cymbopogon obtectus* and *Eriachne mucronata*) under water stress compared to the control treatment.

Conclusion & Significance: Priming has a positive effect on germination parameters such as total germination and speed for seeds under certain water stress; however, this positive effect decreases when water stress is high (-1.0 MPa). This study assists in better understanding how to improve germination of native species from the arid Pilbara which will improve the success of future revegetation programs.

29. POSTER FOR COMPETITION

Accommodation, sediment supply and deltaic process regime: Controls on deep-water sand delivery beyond the shelf-edge

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The Lower Barrow Group (LBG; Latest Tithonian – Early Valanginian) is a moderately deep-water shelf-margin that prograded during a late phase of rifting. This system was affected by major variations in sediment supply and subsidence, leading to a significant variability in shelf-margin architecture through time and space. A 3D semi-automatic, full-volume seismic interpretation workflow allowed identifying 73 high-order clinothems presenting an average time span of ~63,000 years. Here, we use 30 of these clinothems from the *D. lobispinosum* interval (142.3-140.9 Ma), to conduct a quantitative analysis of the shelf-margin architecture, paleoshorelines processes and deep-water systems. Based on a process-based classification, four types of hydrodynamic regimes were identified along paleoshorelines: wave-dominated (W); wave-dominated, fluvial-influenced and tide-affected (Wf*t*); fluvial-dominated, tide-influenced and wave-affected (Ft*w*); and fluvial-dominated and tide-influenced (Ft). Similarly, four types of deep-water systems were recognized: sheet sands, MTDs, short and long run-out turbidite systems. Low *A/S* conditions on the shelf were associated with sediment bypass to the continental slope, whereas high *A/S* conditions were linked with increasing sediment storage on the shelf. While fluvial to wave processes can be dominant in all *A/S* conditions, fluvial-dominated coastlines are dominantly associated with steep clinoform slope gradients and more mature, longer run-out turbidite systems, reflecting high rates of sediment supply at river mouths and hyperpycnal flows as an important trigger mechanism for the initiation of turbidity currents. Conversely, wave-dominated shorelines are linked to low-angle clinoform slope gradients and no to poor turbidite system development (unchannelized sheet sands and MTDs), leaving a starved slope where sediments are dominantly transported laterally in the form of mud belts. Due to (1) the shallow configuration of the margin (<500m), (2) the presence of short slopes, (3) an overall high sand-to-mud ratio and (4) the presence of small and likely short-lived fluvial feeder systems, the turbidite systems of the LBG are smaller scale (<50 km) and probably shorter lived than most modern turbidite systems (100-1000 km). These variations are observed both through time and space (within a single clinothem) indicating that laterally varying *A/S* ratios and coastal processes strongly impact the three-dimensional stratigraphic architecture of shelf-margin sequences, and the distribution of shallow- and deep-marine reservoirs.

30. POSTER FOR COMPETITION

Research and stakeholders: Bathynellidae (Bathynellacea, Crustacea) case studies in mining areas. New genera from Australia with fascinating patterns of distribution

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It seems obvious to say that research can provide benefits to multiple stakeholders and that stakeholder involvement is more often than not essential for research to proceed. Concrete examples of these mutual dependencies are valuable, where industry, government agencies and biological studies increase each others' potential and efficiencies.

In the past 20 years the number of subterranean taxa discovered in Australia, especially in the Pilbara bioregion, has increased consistently thanks to environmental and biological surveys, often associated with mining development, but the investment on research needed to understand this vast biodiversity is far from what is required.

Bathynellidae occur in most Australian aquifers, but collecting them is not simple and their study and identification are very difficult due to their small and fragile bodies and their conservative morphology. Additionally, the poor and incomplete description of the type genus and species of this family (*Bathynella natans*) have led to the assignment of many species occurring around the world, including Australia, to this genus. The taxonomic framework is therefore not well defined and their biodiversity and distribution assessments needed by government agencies become challenging. This research started with a collaboration with different environmental consultants who provided a conspicuous number of specimens collected through several years, which allowed an accurate analysis of specific aquifers. Studies of Bathynellidae populations occurring in different areas produced results useful to inform mining companies on species distribution and groundwater connectivity, underling the importance of cooperation among stakeholders. Morphological and molecular data reveal new genera and species with fascinating relationships.

This example demonstrates (again) the value of research as both underpinning and supplementing, existing knowledge to improve the management and monitoring of the delicate subterranean environment and its resources.

31. POSTER FOR COMPETITION

Temporal and spatial patterns of the Australian kelp holobiont

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Macroalgae are ecologically important and provide many essential roles in marine ecosystems. The health, resilience and ecological functioning of macroalgae are influenced by interactions with the associated microbiome. This functional relationship forms a single entity referred to as the 'holobiont'. Little is known about prokaryote diversity within the kelp holobiont and how these communities shift temporally, but time series experiments are one method that can be used to inform how microbial diversity or community structure can alter and stabilise over time. This study aimed to determine the spatial and temporal patterns of microbial communities on the dominant Australian kelp, *Ecklonia radiata*.

Holobiont samples were taken from two reefs within the Marmion Marine Park in Western Australia across a 14-month sampling period. The two sites, Wreck Rock and Centaur Reef, are natural representative reefs located approximately 1 km and 4 km offshore at depths of 4 m and 12 m respectively. Both sites displayed similar patterns in microbial community abundances and diversity until a storm event occurred in May 2016. The impact of the storm induced a shift in kelp microbial community composition, producing significantly different community abundance at each site. One of the effects was the bacterial abundances from the genus *Tenacibaculum* substantially increased in winter at both sites, particularly at the inshore Wreck Rock location. Some *Tenacibaculum* are known to play a vital role in the carbon cycle, but are associated with marine pathogens, such as the 'Salmon winter-ulcer disease'. Subsequently, during summer, the microbial community patterns at each site returned to a similar consistent state. To our knowledge, this study represents one the most comprehensive kelp holobiont studies in Western Australia. Overall, the kelp microbiome exhibited high stability, suggesting resilience under a range of environmental conditions, a promising result for the health of kelp in future climatic conditions.

32. POSTER FOR COMPETITION

The costs of isohydry: mortality and hydraulic control strategies in woodlands under severe drought stress

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Catastrophic and widespread tree mortality events around the globe have been linked with increased temperatures and more frequent/severe droughts events. Sudden large-scale Banksia woodlands mortality in the south-west of Western Australia (SWWA) is being reported, particularly after extreme dry and hot summer seasons. Environmental stresses (e.g. drought, heatwaves) can induce a decline in leaf water potential (Ψ_{LEAF}), putting plant water systems under tension, promoting embolism formation and ultimately plant death. We investigated the seasonal relationship between Ψ_{LEAF} (Ψ_{PD} and Ψ_{MD}), stomatal conductance (g_s) and tree mortality during a record dry and hot summer in SWWA. Four co-occurring tree species (*Allocasuarina fraseriana, Banksia menziesii, Corymbia calophylla, Eucalyptus marginata*) were selected in two sites within a woodland. The sites differing in groundwater depth and plant density allowed the evaluation of seasonal effects of drought and elevated temperatures between species/sites. There were strong contrasts in hydraulic strategies to cope with reduced soil water availability and increased atmospheric evaporative demand. *E. marginata* and *A. fraseriana* showed anisohydric control of Ψ_{PD} and Ψ_{MD} allowing more negative Ψ_{leaf} with declining soil moisture. *C. calophylla* showed strong Ψ_{leaf} control, leaning towards an isohydric strategy, however allowing further Ψ_{LEAF} decline than *B. menziesii. B. menziesii* exhibited the strictest Ψ_{LEAF} control along the season, maintaining the highest Ψ_{PD} and Ψ_{MD} between species and sites, a markedly isohydric response. This strategy, although seemingly advantageous during seasonaly dry conditions, may lead to physiological failure during severe drought/temperature stress, which may partly explain the widespread mortality of *B. menziesii* in the region.

33. POSTER FOR COMPETITION

Bushland fragments vs. residential gardens: which are better for native bees in a biodiversity hotspot?

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Perth, the capital city of Western Australia, is situated in the southwest Western Australian biodiversity hotspot, renowned for its diverse and endemic native vegetation. Much of the original vegetation has been cleared, leaving remnant bushland fragments within an urban matrix, but new vegetated patches, in the form of residential gardens have been produced.

Despite native bees being key pollinators across ecosystems, little is known of their resilience to urbanisation - a leading cause of land-use modification. With Perth's human population expanding, remnant bushland is under threat from urban sprawl; it is therefore crucial to determine the value of these urban bushland fragments for native bees, and whether residential gardens also serve as quality habitat.

A comprehensive study was undertaken into native bee communities, investigating the role of gardens versus bushland fragments in supporting diversity and abundance of native bee communities. Seven residential gardens and seven bushland remnants were surveyed once a month from Nov – Feb 2016/2017 using sweep-netting, trap-nests, and a range of passive sampling techniques.

It was discovered that whilst there was no significant difference in abundance of honeybees between bushland fragments vs. residential gardens, native bees were significantly more abundant and had a significantly greater species richness in bushland than residential gardens.

It can be concluded that whilst residential gardens can host native bees, bushland remnants are indispensable if we are to conserve the full suite of native bees in urban areas.

34. POSTER FOR COMPETITION

Age revision of the Miocene coral-rich limestones from the Cape Range Anticline, Western Australia

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Small outcrops of Miocene coral-rich limestones are widespread in the eastern part of the Cape Range Anticline (CRA). These limestones are mapped as "Trealla Limestone". Biostratigraphic analysis was undertaken in the type section of the Trealla Limestone by Crespin (1955) and Chaproniere (1975), who assigned it to the Middle Miocene. Later studies took this age for granted, and all the outcrops of Miocene coral-rich limestones from the CRA were considered of Middle Miocene age.

These outcrops are undergoing new investigations, as they belong to the poorly understood heterogeneous Miocene carbonate system in the Northern Carnarvon Basin. The heterogeneity of this system is a major issue for the oil industry, and it is simultaneously a drilling hazard and a source of noise in seismic data. These inconveniences will only be reduced if the entire carbonate system is better understood. Moreover, similar Miocene coral-rich limestones were observed all over Western Australia, from the Bonaparte Basin to the Eucla Basin. Several attempts of correlation were realised, but the age uncertainty was too high to provide robust results. A good age constraint on the evolution of this different limestones through time would improve the understanding of the Miocene climatic and oceanographic history of WA.

This study provides the first age revision of the Trealla Limestone in the CRA, and reveals the existence of three different foraminiferal assemblages. The limestones from Mount Lefroy (southern CRA), which include the Trealla Limestone type section, are characterised by the association *L. (N.) ferreroi*, *Flosculinella globulosa*, *F. bontangensis*, *Austrotrillina asmariensis*, *A. striata* and *Globigerinatella insueta*. *Orbulina spp.* and *Marginopora vertebralis* are absent. This indicates a deposition during the N7-zone/Lower Tf1-"stage" (eq. late Early Miocene; ~17.62 to 17.69 Ma), and not during the Middle Miocene as previously determined. The limestones from Mowborra Creek (central CRA) contain *F. bontangensis*, *A. asmariensis*, *A. striata*, *Orbulina suturalis* and *O. universa*, which indicate a deposit during the N9 or N10-zones/Middle to Upper Tf1-"stage" (eq. Middle Miocene; ~15.10 to 13.74 Ma). The outcrops located around Exmouth (Northern CRA) contain *Paragloborotalia mayeri* and *Sphaeroidinellopsis ssp.* (S. subdehiscens?). This association, which still need to be confirmed, suggest a deposition during the N11-N14 zones/uppermost Tf1 to lower Tg-"stage" (eq. upper Middle Miocene/lower Late Miocene; ~13.74 to 10.5 Ma).

35. POSTER FOR COMPETITION

Life at the edge: Mechanisms and drivers of calcification in corals at their latitudinal limits

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High-latitude coral reefs provide natural laboratories for investigating the mechanisms and limits of coral calcification. While the calcification processes of tropical corals have been studied intensively, little is known about how their temperate counterparts grow under much lower temperature and light conditions. Here we report the results of a long-term (2-year) study of seasonal changes in calcification rates, photo-physiology, and calcifying fluid (cf) chemistry (using boron isotope systematics and Raman spectroscopy) for the coral *Turbinaria reniformis* growing near its latitudinal limits (34.5°S) along the southern coast of Western Australia. In contrast to tropical corals, calcification rates were found to be three-fold higher during winter (16 to 17°C) compared to summer (~21°C), and negatively correlated with light, but had no correlation with temperature. These unexpected findings are attributed to a combination of higher chlorophyll *a* and hence increased heterotrophy during winter compared to summer together with the corals' ability to seasonally modulate pH_{cf}, with carbonate ion concentration $[CO_3^{2-}]_{cf}$ being the main controller of calcification rates. Conversely, calcium ion concentration $[Ca^{2+}]_{cf}$ declined with increasing calcification rates; resulting in aragonite saturation states Ω_{cf} that were stable yet elevated by x4 above seawater values. Our results show that corals growing near their latitudinal limits exert strong physiological control over their calcifying fluid in order to maintain year-round calcification rates that are insensitive to the unfavourable temperature regimes typical of high-latitude reefs.

Reference: Ross CL, Schoepf V, DeCarlo TM, McCulloch MT. Mechanisms and seasonal drivers of calcification in the temperate coral *Turbinaria reniformis* at its latitudinal limits. *Proceedings of the Royal Society B* (in review).

36. POSTER FOR COMPETITION

Heavy metal incorporation in foraminiferal calcite: multi element short-term enrichment culture experiments with *Amphisorous hemprichii*.

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Large benthic foraminifera (LBF) are important marine calcifiers and are potential candidates to reconstruct environmental parameters because of their large size. *Amphisorous hemprichii*, a species of LBF, were collected from the Rottnest Island, located approximately 18 km off the coast of Perth in WA, to study anthropogenic pollution in the island. The samples were cultured in the laboratory under constant salinity, temperature and pH conditions similar to that of seawater. In the first phase, we will try to understand heavy metal incorporation in *Amphisorous hemprichii*. Thirteen samples were handpicked and cultured individually in petri dishes filled 3/4th with filtered seawater for 12 weeks before the start of the experiments. The filtered seawater was replaced every third day. These thirteen samples were spiked with heavy metals such as Cd, Cu, Pb, Mn, Ni and Zn for two weeks. The spike concentration was prepared at double the 80% level of protection of species in marine water as mentioned in the Australian and New Zealand guidelines for fresh and marine water quality. The samples were changed to normal filtered seawater after two weeks and cultured further for a period of two weeks before performing laser ablation studies on their tests.

37. POSTER FOR COMPETITION

Dressing up as pea plants: behavioural and morphological evidence for Guild mimicry in an Australian orchid

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Background and Aims: While there is increasing recognition of Batesian floral mimicry in plants, here are few definite cases where mimicry involves a guild of model species. Here, we test for pollination by guild mimicry in *Diuris*, a genus hypothesized to attract pollinators via mimicry of a range of co-occurring pea plants (Faboideae).

Methods: Observations of pollinator behaviour were made for *Diuris brumalis* using artificial clumps of flowers. Candidate model species were identified based on the food plants of pollinators. An analysis of floral traits in the co-flowering community and spectral reflectance measurements, were undertaken to test if *D. brumalis* and the pea plants showed strong similarity and were likely to be perceived as the same by bees. Pollen removal and fruit set were recorded at 18 sites over two years to test if fitness of *D. brumalis* increased with the abundance of the model species.

Key Results: *Diuris brumalis* shares the pollinator species *Trichococolletes capillosus* and *T. leucogenys* (Hymenoptera: Colletidae) with co-occurring Faboideae from the genus *Daviesia*. On *D. brumalis*, *Trichocolletes* exhibited the same stereotyped food-foraging and mate-patrolling behaviour that they exhibit with *Daviesia*. *Diuris* and pea plants showed strong morphological similarity compared to the co-flowering plant community, while the spectral reflectance of *Diuris* was similar to *Daviesia* spp. Female fitness of *D. brumalis* was highest at sites where *Daviesia* spp. were present, and pollen removal was highest at sites with high *Daviesia* abundance.

Conclusions: *Diuris brumalis* is pollinated by mimicry of a guild of co-occurring congeneric Faboideae species. The specialized nature of this pollination system suggests that it may be vulnerable to pollinator loss in fragmented landscapes. Interestingly, *D. brumalis* belongs to a complex of species with similar floral traits, suggesting that this represents a useful system for investigating speciation in lineages that employ mimicry of food plants.

Key words: *Diuris brumalis*, *Daviesia*, Faboideae, Colletidae, mimicry, food deception specialization, pollination, pollinator behaviour, fitness

38. POSTER FOR COMPETITION

Palynology and palynofacies associations of Late Triassic assemblages from the Mungaroo Formation, Greater Gorgon Area, Western Australia.

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The Northern Carnarvon Basin (NCB) has witnessed several major hydrocarbon developments in recent years including Chevron's Gorgon project. Drilling in the Gorgon area has resulted in the acquisition of several very long continuous conventional cores in the gas-bearing Mungaroo Formation, a thick, laterally extensive fluvio-deltaic unit ranging in age from Ladinian to Rhaetian. These cores provide an exceptional opportunity to investigate the palynology and palynofacies associations of the wide range of depositional environments ("depofacies") and lithofacies found in the Mungaroo Formation.

Based on sedimentological studies and wireline log analysis, various facies associations were recognized in the Mungaroo Formation cores in fluvial channel, floodplain, crevasse splay, distributary channel and tidal zone paleoenvironments. Sediments as varied as laminated mudstones, massive siltstones, immature soils showing pedogenic alteration, coals and cross-bedded fine to coarse-grained sandstones are represented in the cores.

This poster outlines the results of preliminary work on 92 samples from four wells in the Gorgon area. The samples were collected from the upper *Samaropollenites speciosus* and lower *Minutosaccus crenulatus* Zones and processed using standard palynological techniques. The palynological and palynofacies assemblages in these samples are correlated with their depofacies and lithofacies in order to enhance understanding of the complex Mungaroo Formation.

Although *Falcisporites australis* dominates most palynofloras, in some cases contributing over 90% of the assemblage, there is a greater diversity of spores than pollen in most associations. *Dictyophyllidites harrisii* is also abundant in some paleoenvironments, and in Central Gorgon-1. Several types of assemblages can be distinguished according to taxonomic composition and abundance of spores. These results suggest that a mosaic of diverse and distinctive plant associations characterized the vegetation of the Middle to Late Triassic deltaic environments of south-eastern Gondwana as has been documented in north-western Europe. The study also demonstrates that detailed palynological analysis of economically significant intervals can add valuable insights into reservoir and source rock characterization.

Ongoing work is aimed at strengthening and expanding these initial results by increasing the number of samples examined, broadening the range of depofacies and lithofacies examined, and improving the taxonomy and biostratigraphic zonation of the Carnian-Norian in the NCB.

39. POSTER FOR COMPETITION

Infestation patterns of *Phoracantha semipunctata* (Coleoptera: Cerambycidae) corresponding with a drought-induced dieback event in native host trees in southwestern Australia

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An outbreak of the native Eucalyptus longhorned borer (*Phoracantha semipunctata*, Coleoptera: Cerambycidae) coincided with a severe drought-induced dieback event in the Northern Jarrah Forest of southwestern Australia over 2010/2011. Although the behaviour of *P. semipunctata* is well known where it is exotic, little is known about its ecology in its native habitats throughout Australia. Trees within drought affected sites were rated according to their crown health and the severity of damage made by larvae consuming phloem/sapwood tissues during their development. Intensive whole-tree sampling was used to investigate host preference and within-tree infestation patterns in *Eucalyptus marginata* and *Corymbia calophylla* trees during the outbreak. Colonisation was similar between host tree species, while there was significantly greater larval survival in marri with 46% more emergence holes m^{-2} compared to jarrah. Sapwood damaged from developing larvae was extensive, being greatest in the most severely drought affected trees. Significant negative correlations were found between density of emergence holes with tree height, with borers concentrated in the lower tree sections. This study is first to establish the association between drought and outbreak levels of *P. semipunctata* and describe the within-tree distribution of the beetle in susceptible hosts within the jarrah forest. This beetle can rapidly establish populations following drought mortality, raising questions about the future impact of *P. semipunctata* infestations with projected increases in warming and drying within the region.

40. POSTER FOR COMPETITION

Oil yields for *Allanblackia parviflora* in Ghana: the effects of oil extraction methods, tree morphology and environmental characteristics

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The study provided a foundational understanding of the oil yields from the fruit of *Allanblackia parviflora* trees in Ghana. Based on an investigation of 157 trees distributed in 16 communities, the study sought patterns of variations in oil yield between trees, between communities and the ecological zones in which it is endemic. Both ecological zone and soil properties were considered as a surrogate for growing conditions associated with tree and fruit morphology. The manual screw press which is one of the most efficient and convenient method of extraction was used to extract the kernel and seed oils. Kernel and seed oil yields ranged from 31.3 – 61.8% and 0.2 – 36.8% respectively.

Large variations were observed between individual trees, and significant oil yield differences were observed between the 16 communities. There were no relationships between oil yields and soil properties even though tree to tree differences were observed. The farmers' estimated ages of the trees predicted kernel oil yields. Very young and very old trees, based on estimated ages by farmers, revealed medium and low kernel oil yields respectively. Kernel oil yields were also seen to be influenced by ecological zone. Most of the low kernel oil yielding trees were identified in the semi deciduous forest zone (SD), and more trees in wet evergreen forest zone (W) were identified as very high kernel oil yielding trees. This may be due to distinctive prevailing environmental condition in the wet evergreen forest zone. Selection of 'elite' trees for domestication can be based on tree phenotype and providing environmental condition similar to the wet evergreen forest zone.

41. POSTER FOR COMPETITION

Microbial diversity and nitrogen fixation in biological soil crusts of Mid West, Western Australia

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Biological soil crusts (BSCs) are communities of cyanobacteria, algae, fungi, and bryophyte commonly found in arid and semiarid regions. It is estimated that they cover approximately 12% of global terrestrial surfaces (Rodriguez-Caballero et al. 2018). Functionally, they regulate soil hydrology, reduce soil erosion and fix atmospheric carbon and nitrogen. While their morphology and ecological functions have been relatively well-documented, characterisation of their microbial constituents has only begun with the advent of next-generation sequencing. Despite two-thirds of Australia's land mass being comprised of arid and semiarid climate, little is known about native BSCs, especially in Western Australia.

Using 16S rRNA amplicon sequencing, this study examined the bacterial communities in various types of native BSCs found in the Midwest region of Western Australia. The levels of diversity and community structure in these BSCs were compared to those found in their underlying soil and un-crusted bare soil. Chemical analyses were conducted to determine best environmental parameter to explain diversity.

BSC-driven nitrogen fixation was thought to be a significant source of soil N in arid ecosystems, with approximately 24 Tg fixed annually (Rodriguez-Caballero et al. 2018). To better understand the potential for nitrogen fixation across various types of native BSCs, we measured the amplification of *nifH* genes using quantitative PCR and their ^{15}N isotopic signature. We hypothesised that BSCs would produce higher *nifH* gene abundance and have ^{15}N isotopic signature more similar to atmospheric N, compared to those found in soil.

Characterisation of the microbial diversity and function within these BSCs allows us to assess their contributions to nitrogen cycling in natural ecosystems and their potential as ecosystem engineers in degraded landscapes.

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42. POSTER FOR COMPETITION

High resolution NanoSIMS imaging reveals microbial mediation of organic nitrogen uptake by seagrass leaves

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Seagrass meadows are extremely productive aquatic ecosystems and seagrass tissues support abundant and diverse epiphytic microbial communities, the microbiota. Microorganisms play a critical role in nitrogen (N) cycling by mineralising dissolved organic nitrogen (DON) into inorganic forms (DIN). Although DIN is crucial for seagrass growth, the significance of heterotrophic microorganisms on seagrass leaves in facilitating the plant's ability to uptake N from DON has been largely overlook. Here, we tested whether seagrass leaf microbiota, through the conversion of DON into DIN, mediate the assimilation of this nutrient by seagrass leaves.

We exposed seagrass (*Posidonia sinuosa*) leaves, with and without microorganisms, to ^{15}N-enriched amino acids (treatments) and ^{14}N-amino acids (controls) over 12 hours. Epiphytes and microorganisms were removed through scraping visible organisms combined with incubation with antibiotics. Samples were collected after 0.5, 2, 6 and 12 hours from isotopically-enriched amino acid spike. Seagrass leaves and epiphytes were firstly examined using isotope mass spectrometry (IRMS), after which a subset of samples was analysed by high-resolution mass spectrometry (NanoSIMS) to show ^{15}N accumulation into microorganisms on the leaf surface and disctrete sub-cellular components (cell wall, cytosol, vacuole and chloroplast) of seagrass leaves.

Both IRMS and NanoSIMS analysis showed high accumulation of ^{15}N within seagrass leaf tissues with an associated microbiota, but not in plants devoid of microorganisms. We show that leaf associated microorganisms fulfil a nutrient-supply role for seagrasses by processing DON into forms available for uptake by the plant, thus enhancing growth and productivity of these important coastal ecosystems.

43. POSTER FOR COMPETITION

Assessing terrestrial metabarcoding of multiple substrates for biological auditing

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Biological surveys are challenging, expensive, and time consuming, yet crucial for both biodiversity conservation and ecological restoration. Metabarcoding is a disruptive technology that can enable biological auditing from DNA in the environment, and may provide cost-effective monitoring, which can detect flora, fauna and microbial communities. Metabarcoding involves the use of next generation sequencing to sequence barcode regions of the genome to determine the community composition of a sample. These samples can be soil, scat, arthropods, and plant material. This study aims to test multiple substrates (soil, ant middens, scat, plant material, arthropods in pitfall and vane traps) to determine what organisms can be detected from each and where they overlap, as well as how many samples of each may be necessary. Samples were collected in the Pilbara and Swan Coastal Plain region of Western Australia and transported to facilities in Perth where the DNA was extracted, amplified and sequenced using multiple primers and targeting multiple gene regions. Preliminary results indicate that soil samples, despite showing promise for biological auditing in some regions, yields very little plant or animal DNA. While soil samples are necessary to determine soil microbial communities, they may be less able to represent flora and fauna communities. Likely, this is a result of the high temperatures and UV radiation of these Western Australian regions, both of which degrade DNA. Bulk samples, such as arthropods from pitfall traps and vane traps, show far greater promise as DNA is extracted directly from homogenized arthropod samples. The goal of this study is to provide a guide for terrestrial metabarcoding sample collection to be used for biological surveys, particularly in subtropical and Mediterranean regions.

44. POSTER FOR COMPETITION

New dinoflagellate cyst marker species from the Bathonian–Kimmeridgian of the North West Shelf, Australia.

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The Late Jurassic strata of the North West Shelf (NWS) of Australia contain numerous world-class oil and gas fields, which remain the focus of significant investment from major international oil companies. This study investigates the geographic and stratigraphic range of unpublished Bathonian–Kimmeridgian dinoflagellate cyst marker species, through biostratigraphic and taxonomic analyses. Palynofloral assemblages from new and legacy palynological preparations from the Alaria-1 and Laminaria-2 wells (Laminaria High, Bonaparte Basin), and Elm-1 and Taltarni-1 wells (Vulcan sub-basin) were documented. The immaculately preserved Oxfordian palynomorph assemblages from the Janzs-Io Field (Northern Carnarvon Basin) were also reviewed and existing stratigraphic data (Sinclair 2012) was incorporated herein.

From these samples nine species of dinoflagellate cyst, and 1 species of uncertain affinity are formally described. Sixteen marker species of dinoflagellate cyst described by Riding & Helby (2001d–f) were imaged using Scanning Electron Microscopy for the first time, further documenting the intraspecific variation of these taxa. Third generation FIB-SEM imaging was used to produce high resolution cross-sections of multi-layered dinoflagellate cysts species to further investigate wall structure in high detail.

High resolution palynological analyses from wells in the Bonaparte Basin and Vulcan Sub-basin were used to identify correlatable biostratigraphic events; this data was then compared to existing palynolostratigraphic studies from the NWS to determine the geographic range of these events. From these analyses several new regional marker events for the Callovian–Kimmeridigian have been identified and corroborated in both the Bonaparte and Northern Carnarvon Basins. These events increase the biostratigraphic resolution of the existing Mesozoic Dinocyst Zonation of the NWS (Partridge et. al. 2006; MGP 2014). This work presents key findings of a PhD project aiming to refine the biostratigraphic zonation of the *Wanaea indotata–Dingodinium swanense* dinoflagellate cyst zones of the Bonaparte Basin.

45. POSTER FOR COMPETITION

Extreme summer rainfall event influences seagrass resilience in unexpected ways in an iconic estuary, Western Australia.

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Extreme climate events (ECEs) are having unprecedented impacts on ecosystem resilience but our ability to predict these effects is limited due to our lack of understanding on thresholds and the effect of multiple stressors. Here, we demonstrate the response of the dominant seagrass *Halophila ovalis* to an extreme rainfall event which produced flooding in the Swan-Canning Estuary, Western Australia in early summer of 2017. This event resulted in rapid changes in salinity, light and nutrient delivery causing seagrass decline and adverse impacts to estuarine condition. Utilising an approach developed for marine heat waves, we defined this extreme event as the period during which salinity differed from background conditions by ≥ 5% and quantified metrics relating to the duration and intensity of the flood. Plant traits that reflected resistance (e.g. cover and biomass) and recovery (e.g. growth potential and seed bank density) were measured at six sites along the estuarine gradient, before, during and after the ECE. Site and temporal variation was significant ($p < 0.05$). Widespread defoliation was evident within one month at upstream meadows where the event persisted for 88 days with salinity declines of 20 PSU. At downstream meadows, the event duration was shorter (79 days) and changes in salinity were less severe (±15 PSU). Despite experiencing lower physical impact, biomass at downstream sites declined by 72% (±15SE) within two months compared to 24-57% (±14SE) at upstream sites. The period of resistance was similar across sites with significant declines in plant traits evident within one to two months. In contrast, the recovery time for plant traits to return to pre-flood levels varied between sites, with longer times at downstream sites. Cover, biomass and leaf density returned to pre-flood levels ($p > 0.05$) over five to eight months at the upstream meadows but not at the downstream sites during the period of this honours project. Consistently higher seed bank densities at the downstream meadows did not appear to accelerate the recovery process. Acclimation to freshwater exposure may explain the greater resilience of upstream meadows compared to downstream meadows. Under projected increases in the intensity and frequency of ECEs, this understanding of local scale variation in the resilience of seagrass meadows will be important to implement adaptive management and assist in mitigating the loss of less resilient seagrass meadows.

46. POSTER FOR COMPETITION

Carbon utilization mechanisms of halophytes from Shark Bay, WA.

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Drought and salinity have a profound negative impact on plant physiology. Photosynthesis, the essential physiological process in all green plants, is severely affected by this stress. Some plants possess flexibility in their C3 and C4 photosynthetic carbon fixation pathway and this increases their tolerance to elevated ambient salinity and temperature. Birridas, ancient landlocked saline lakes, distributed over Shark Bay of WA offer a unique model to test the influence of ambient salinity stress on plants. Halophytes, salt-tolerant plant species, growing in the Birridas along salinity gradient form a characteristic zonation pattern. Furthermore, plants experience re-occurring anoxic stress resulting from repeated flooding events in Birridas. Biotic interactions, notably with the root-associated microbiome (eukaryotes, bacteria and archaea) also may play an important role in the plant fitness and community assembly. These environmental stresses act as filters shaping ecological and evolutionary adaptation of plants.

The overall objective of this project is to investigate salt tolerant plants (halophytes) that grow along salinity gradients in Birridas to improve our understanding of the physiological adaptation mechanism of plants to stress. In particular we will attempt to understand the impact of salinity on the carbon utilization mechanisms of salt-tolerant plants. Compound specific stable carbon isotope analyses are conducted on plant lipids to elucidate the carbon fixation pathways of plants growing under elevated salinities. Preliminary stable isotope analyses on some halophytes from the Shark Bay area suggests the ability to switch between C3 and C4 carbon assimilation pathways. Furthermore we investigate the impact of salinity on the lipid distribution of salt-tolerant plants. Analyses of plant leaf waxes revealed a species specific *n*-alkane pattern along soil salinity gradients.

Rhizosphere microbiomes may also play a role to shape adaptation of halophytes, and eventually drive patterns of plant community assembly. Soil microbial communities will be examined from plant rhizosphere to see if microbial communities associated with plant roots change along a salinity gradient and have the metabolic potential to support plant growth under stress conditions.

47. POSTER FOR COMPETITION

Microbial mats from Shark Bay (Western Australia) and the role of microorganisms and viruses during petroleum biodegradative experiments

Yalimay Jiménez, Marco Coolen and Kliti Grice

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Viruses represent only 5% of total biomass of microbial mats but are significantly more abundant than bacterial and archaeal communities. Viruses play an important role in nutrient cycling and the evolution and genetic and functional diversity of microorganisms. A number of previous studies have demonstrated that bacteria in microbial mats are involved in degradation of petroleum compounds, but the role that viruses play in regulating these and other bacteria in microbial mats remains unknown.

This research study will explore the role of viral communities in microbial mats from a hypersaline environment in Shark Bay (Western Australia), and their potential role in biodegradation of petroleum. Smooth (SMM) and Pustular (PMM) microbial mats samples have been collected from Nilemah embayment and exposed to petroleum during a time series incubation experiment. Changes in microbial and viral diversity, microbial metabolic potential to degrade petroleum hydrocarbons, and the expression of genes involved in these processes will be monitored using high throughput sequencing of respectively taxonomic marker genes, metagenomes, and metatranscriptomes. Changes in the hydrocarbon profiling and stable isotopic compositions of individual biomarkers associated with microbial decomposition of petroleum will be determined in parallel using state-of-the-art organic and isotope geochemistry tools.

The results will then lead to enhance the current knowledge of microbial and viral composition of Shark Bay microbial mats, their susceptibility to petroleum introduced into this ecosystem, provide insights how virus affect or regulate hosts during a petroleum spill experimentation, and evaluate comprehensively hydrocarbon and isotopic composition over time. This research become more relevant due to it is anticipated a 0.5-m sea-level rise for the next decades and it will lead to a higher probability of petroleum being introduced into the Shark Bay region because of increased shipping and transportation activities.

48. POSTER FOR COMPETITION

Preservation conditions of soft tissue and bone material in anaerobic environments using microbialites from Shark Bay, WA

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The fossilization processes of soft tissue and bone structure are complex with many stages from burial to the actual discovery as a fossil. Organisms rapidly buried in anoxic sediments can result in exquisite fossils with remarkable soft tissue preservation (e.g. Melendez et al., 2013a, 2013b). Recently it has been shown that photosynthetic anaerobic bacteria and sulfate reducing bacteria play a pivotal role in exceptional fossil preservation (Melendez et al., 2013a, 2013b). Concretions and microbialites are organosedimentary deposits, which accumulate as a result of active microbial communities, might play a crucial role in encapsulating and preserving organic tissue over time. Recently an exceptionally well-preserved 183 million year old Ichthyosaur bone, still harbouring intact blood cells and collagen fibres and dietary cholesterol was discovered (Plet et al., 2017). This finding led to the following questions. What kind of environmental conditions must have been present to optimal preserve this cellular and fibrous material? How fast, after the death of the organism, did the fossilisation process start to preserve it in this extraordinary way? The Marine sediments of Shark Bay region offer a unique opportunity to test tissue preservation processes. Shark Bay sediments harbour unique microbial mats (including anaerobes) and microbialites that are considered modern analogues of ancient stromatolites dating back about 3.5 billion years to the Archaean period. Incubation experiments of soft tissue and bone material using microbial mats from Shark Bay will enhance our knowledge of early microbial encapsulating processes and the formation of carbonate concretions. Soft tissue and bone material from a crocodile is incubated with microbial mats from Shark Bay to monitor microbial encapsulation processes and study how fast the formation of carbonate concretion occurs under natural oxygen depleted burial conditions. Furthermore, fossilization processes of soft tissue and bone material of a crocodile will be investigated using anaerobic conditions with different sulphide and iron concentrations.

OTHER POSTERS: ABSTRACTS
(Not for competition)

University Club Banquet Hall, UWA

Authors have sole responsibility for the content of their Abstract and poster

1. Other Poster

Sub-bottom profiling and growth patterns of Kimberley coral reefs, North West Australia

Giada Bufarale, Lindsay B. Collins, Michael O'Leary,
Moataz Kordi, Tubagus Solihuddin, Alexandra Stevens

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The Kimberley region is located on the north western continental margin of Australia and is characterised by unique and complex geology and geomorphology, significantly influenced by the macrotidal range systems (up to 11 m), which result in expansive intertidal zones.

A total of 300 km of high-resolution shallow imaging data were acquired during a sub-bottom profiling (SBP) study of various southern Kimberley reef settings. Acoustic datasets were collected with a Boomer SBP system covering reefs where remotely sensed images were previously used to produce geomorphic and substrate classification maps.

A classification diagram has been developed on the basis of imaging of internal structures. Vertical and lateral differences were identified and categorised according to their shape and acoustic reflection characteristics along the hiatuses and internal reflectors.

These new datasets have provided a better understanding of Quaternary reef growth. The pre-existing substrate has influenced the successive morphology of fringing reefs, intertidal platforms and platform reefs. Global sea-level change, controlled by ice age fluctuation events, provides a signal which is recorded in successive stages of the reef growth separated by hiatuses. Two acoustic reflectors can be consistently distinguished across the inner shelf reefs (Sundays Group, Buccaneer Archipelago and Montgomery Reef), marking the boundaries between Holocene reef (Marine Isotope Stage 1, MIS1, last 12,000 years) commonly 10-15 m thick, and MIS 5 (last 125,000 years) and an ancient Neoproterozoic rock foundation over which Quaternary reef growth occurred. Three acoustic horizons characterise the offshore reefs (Adele complex), highlighting multiple reef building stages.

2. Other Poster

Mid-Late Holocene Development of the Mixed Carbonate Clastic System of the Faure Channel-Bank Complex and Wooramel Delta (Shark Bay, Australia)

Giada Bufarale, Lindsay B. Collins

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Registered as a World Heritage Property in 1991, Shark Bay is located on the westernmost coast of Australia, approximately 800 km north of Perth. Shark Bay has an area of around 22000 sq km, of which about two-thirds are occupied by the marine environment. Seagrass is one of the most important features that has contributed to the evolution of the marine ecosystem of Shark Bay, and in particular to the growth of the Faure Sill and juxtaposed Wooramel Delta. The presence of well-developed barrier banks, associated with a semi-arid to arid climate and a restricted water exchange produced and preserves the metahaline and the hypersaline conditions in the southern embayments of Hamelin Pool and L'Haridon Bight, providing a basis for the development of a variety of biogenic and physical structures such as microbial communities (stromatolites) and oolitic shoals.

To investigate the Holocene development of the Faure Sill, remote sensing imagery analysis, shallow acoustic stratigraphy and sedimentological information (core logging, X-Ray diffraction and radiocarbon dating) were combined, in order to correlate internal architecture, sediment body morphologies and lithofacies. The analyses have revealed that the system is a channel-bank complex which consists of mixed bioclastic and quartz sediments. Bioclastic particles are mainly calcareous seagrass epiphytes, including foraminifera, coralline algae, bivalves and other constituents. The source of most quartz is from erosion of the Peron Sandstone, which forms topographic highs such as Faure and Pelican Islands, with minor amounts of terrigenous input (clay minerals) from the Wooramel Delta. Dating values, obtained with the accelerator mass spectrometer method (AMS), were used to estimate the age of the bank onset and to calculate accumulation rates in the bank and delta areas. The results indicate that the development of the bank, during Mid-Late Holocene time, has been controlled by pre-Holocene topography, seagrass and sea level fluctuations.

The Faure complex is an example of a mixed clastic carbonate system that provides an opportunity to study behaviour, architecture, interaction and facies distribution for potential comparison with partial ancient analogues of hydrocarbon reservoirs in the Browse Basin, Western Australia.

3. Other Poster

High productivity of *Peneroplis* including aberrant morphotypes, in an inland pond at Lake Macleod, Western Australia.

Lorenzo Consorti[1, 3], Christopher Ronald James Kavazos[2], Cliff Ford[3], Margaret G Smith[3], David W. Haig[3]

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Extreme growth variability in extant *Peneroplis* has drawn the attention of micropaleontologists since the 19th Century. The variation centres on a basic planispiral mode of growth and involves variation in test symmetry, degree of involute to evolute coiling, and degree of uncoiling in the adult stage. These variances, which still arouse great interest, have been recorded from the Mediterranean Sea to Pacific atolls.

Deformed tests with strange chamber arrangements in benthic foraminifera are sometimes considered an indication of environmental pollution or hypersaline waters. However, recent evidence suggests test deformation may also be influenced by natural phenomena in unusual environments (eg. the presence of mineral submarine springs; or in inland saline water bodies disconnected from the sea that have fluctuating water chemistry). Further explanations suggest deformation in *Peneroplis* occurs in juvenile gamonts.

There is general agreement that the mechanisms of aberrations in recent populations of *Peneroplis* are natural and ascribed to intraspecific variation. For these reasons, some authors questioned the systematic relationships among the living species recognized in *Peneroplis* (viz. *P. planatus* (Fichtel and Moll), *P. pertusus* (Forskål); *P. arietinus* (Batsch); *P. proteus* d'Orbingy; *P. antillarium* d'Orbigny), and other authors have also grouped all or some of these as synonyms. In this study, we explore the variation in an exceptionally abundant population of *Peneroplis* from Pete's Pond, a permanent wetland, within Lake Macleod Evaporate Basin, Western Australia. The area is unusual because foraminifera are isolated from the nearby ocean, except for a 15-km subterranean karst system that permits a constant delivery of seawater into the pond. Waters from Pete's Pond were analysed, and the results of TDS and Cl values are either less than or at seawater concentration. In this isolated but profilic population we investigate morphological variability of *Peneroplis* which is also the dominant foraminiferal in a highly unusual environment. This study of morphological variation has implications for distinguishing those morphological features influenced by environment from those diagnostic for taxonomic discrimination. This will be important in future studies of the rich geological history of peneroplids from their first appearance during the mid-Cretaceous, and of their evolutionary relationships to other groups such as the Soritidae, supposed descendants of the Peneroplidae based on molecular phylogenetic studies.

4. Other Poster

Dolerite Dykes Characterisation in the Hamersley Basin and Significance for Groundwater Compartmentalisation

Anne-Audrey Latscha, Keith Brown

Rio Tinto Iron Ore

The Brockman Iron (BIF) and Marra Mamba Iron Formations (MMIF) of the Hamersley Group in the Hamersley Basin (in the Pilbara region of Western Australia) host massive iron ore deposits, which are mined by numerous mining companies. Due to the large combined annual extraction, more below the water table resources are being developed. Historically, it was believed groundwater flows unimpeded through the Wittenoom Formation aquifer which may be connected with the underlying or overlying orebody aquifers. However, there is increasing evidence for groundwater to be compartmentalised between hydraulic barriers, largely comprising dolerite dyke intrusions, which prevent or limit hydraulic connection. Groundwater compartmentalisation suggests the lateral extension of groundwater drawdown from mine dewatering is less than previously understood.

The Hamersley Basin is dissected by numerous dolerite dykes from different suites. Certain dykes act as hydraulic barriers and compartmentalise groundwater, however others maintain groundwater flow-through. Compartmentalisation can be predicted based on field assessment of the natural groundwater level. However compartmentalisation can initially be masked, especially if saturated detrital, formed by particles eroded and transported from the ridges of BIF or MMIF, overlies the bedrock aquifer. Compartmentalisation becomes apparent only upon commencement of dewatering, leading to different groundwater responses on each side of the hydraulic barrier.

Early dolerite dyke characterisation can assist with predicting the role of a dyke as a hydraulic barrier before dewatering commences. The extent of dolerite weathering indicates whether the dyke acts as a hydraulic barrier or not. Weathering results in reduction of intrusion thickness and the creation of secondary porosity, formed as a result of leaching of soluble elements and the formation of highly porous weathered products. Fresh dolerite dykes tend to display a more compact texture with interlocking primary minerals with limited to no porosity. Further, delineation of the base of weathering of the dyke assists predictions at which depth compartmentalisation is likely to occur. Determination of these key characteristics of dolerite dykes and potential for compartmentalisation of groundwater should result in more accurate groundwater modelling outcomes

5. Other Poster

Recent advances in understanding of the hydrogeology of the Broome Sandstone aquifer at La Grange, Kimberley

GP Raper, RJ Paul, RJ George, Nicholas Wright & PS Gardiner

Department of Primary Industries and Regional Development

The Cretaceous Broome Sandstone aquifer is an extensive, almost flat-lying formation of the Canning Basin and occurs beneath the Pindan and coastal plain soils of the La Grange area, south of Broome in the Kimberley. Broome Sandstone groundwater is mostly fresh. The Jarlemai Siltstone forms the base of the aquifer and separates it from the Wallal Sandstone aquifer below. Wallal groundwater is brackish and under artesian pressure near the coast.

An airborne electromagnetic (AEM) survey was flown in 2012–13 to provide data on the geometry of the Broome Sandstone and on the saltwater interface (SWI). A drilling program complemented the AEM survey. Strong agreement was found between the base of the Broome Sandstone interpreted from the AEM data and the drilling. The AEM data was much less reliable in defining the top of the Broome Sandstone and suggested that the Broome Sandstone is absent in the east of the area but drilling suggests only a change in lithology.

The AEM data and drilling results identified a deep embayment at the coast in the base of the Broome Sandstone in the centre of the region. Bores logs provided evidence in support of the existence of three palaeovalleys cut into the Broome Sandstone; one identified by Vogwill (2003) and two others previously only identified via remote sensing and terrain analysis by English et al. (2012).

Analysis of groundwater heads supports the theory that wetlands along the interface between the Pindan and coastal mud flats are mostly dependant on the Broome Sandstone aquifer, as are several larger inland wetlands. Smaller wetlands away from the coast are most likely dependent on perched groundwater. The coastal mud flats confine the groundwater of the Broome Sandstone but data is lacking on how far offshore this persists.

Groundwater chemistry and isotope analyses indicate that groundwater at the watertable is recent (<500 y) and is actively recharging at rates of between 11.6 and 16.5mm/y. Groundwater at the base of the aquifer near the coast is greater than 20,000 years old.

The AEM data identified that the SWI extends up to 40km inland from the coast in places. Conventional theory and numerical modelling indicate that if the SWI were in equilibrium with the current groundwater heads and recharge regime it would lay about 7km inland of the coast. A sea level approximately 2m above current levels within the recent geological past and the large tidal range (~10m) in the region are identified as plausible explanations for the shape and location of the SWI.

6. Other Poster

ROV exploration of the Perth Canyon and its deep-water faunas

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The Perth Canyon is a large, steep-walled, subsea valley that incises the shelf margin yet shows no direct landward connection. It provides a conduit for upwelled nutrient-rich waters onto the shelf, which creates a zone of high productivity. The first ROV exploration of this enigmatic canyon, conducted in 2015, was made possible by support from the philanthropic Schmidt Ocean Institute, which provided its ocean research vessel the R/V Falkor equipped with a CTD rosette, multi-beam sonars, and an ROV with high-resolution cameras. The goals were to document the canyon and its inhabitants, characterise the physical structure and chemical compositions of the canyon waters, and strategically sample mainly calcareous deep-sea corals for future geochemical proxy studies.

ROV transects and CTD casts were undertaken at six geomorphologically distinctive locations across the canyon to a maximum depth of 2000 m. The faunas observed throughout the dives included various species of echinoderms, crustaceans, sponges, cnidarians, molluscs, brachiopods, tube worms, fish, and plankton.

Solitary and colonial scleractinian corals and some octocorals were collected mostly from the canyon walls between 674-1815 m. Live solitary (cup) corals were commonly observed, colonial scleractinians were scarce, gorgonian and bamboo corals inhabited most dive sites, and proteinaceous species were also present. Extensive coral graveyards found between ~690-720 m and 1560-1790 m represent ancient reefs of colonial and solitary scleractinians, which yielded U-Th ages from the Last Glacial Maximum (~20 ka) to ~30 ka.

Seawater temperature, salinity, and dissolved oxygen measurements have identified up to six water masses. The faunas sampled inhabited intermediate and deep waters comprising Antarctic Intermediate Water, Northwest Indian Intermediate Water, as well as Indian Deep Water or Upper Circumpolar Deep Water. The carbonate chemistry of these waters show that the calcite saturation state is above unity throughout all depths sampled (≤ 2000 m), whereas aragonite saturation reaches unity at ~1000 m. Thus, some scleractinian corals inhabit depths below the aragonite saturation horizon.

7. Other Poster

Early Miocene (~20.5– 16 Ma) sea-grass meadow deposits, from a probable metahaline environment, interpreted from modern Western Australian analogues

Margaret G. Smith, David W. Haig, Rosine Riera & Justin H. Parker

School of Earth Sciences, The University of Western Australia

Seagrasses provide habitats for a diverse range of marine fauna, both obligate species and species that live part of their life cycle in the meadows. The epibionts within the seagrass meadows are important producers of biogenic calcium carbonate. However, the cellulose structure of seagrass means that preservation of these plants in the geological record is poor and often other lines of evidence are used to infer the existence of seagrass meadows. Modern foraminiferal and sedimentary analogues from Western Australia have been used to determine the palaeoenvironment for the Miocene Trealla Limestone on the Southern Carnarvon Platform (a part of the Southern Carnarvon Basin proximal to the Miocene shore line).

The Trealla Limestone is a foraminifera-rich grainstone, packstone and wackestone with abundant miliolid and rotaliid foraminifera and generally rare mollusc, echinoid and coralline algal debris. The quartz component is usually rare but variable. The age is based on larger benthic porcelaneous foraminifera with diagnostic foraminifera including: *Flosculinella globulosa* Rutten 1917; *Flosculinella bontangensis* Rutten 1913; *Austrotrillina striata* Todd and Post 1954; *Austrotrillina asmariensis* Adams 1968; primitive morphotypes of *Austrotrillina howchini* (Schlumberger 1893); and *Pseudotaberina malabarica* (Carter 1853 and emended by Banner and Highton 1989). These foraminifera place this limestone in the lower Tf1 Letter Stage equivalent to the Burdigalian Stage, late Early Miocene (~ 20.5–16 Ma).

Many of the miliolid and rotaliid foraminifera identified from the rock samples have similar morphotypes living on seagrass leaves within the meadows off the coast around Perth. Procelaneous foraminifera comprise 66.2 ± 2.5 % (23 samples) of the foraminiferal assemblage, with a range of 39–90 %. These percentages are higher than in modern normal marine seagrass meadows of about 34 practical salinity units (psu)* but are comparable to those found in meadows in the metahaline (40–55 psu) parts of Shark Bay, Western Australia. The presence of carbonate-cemented agglutinated foraminifera and echinoid debris is suggestive of salinity less than 50 psu. Based on the modern foraminiferal analogues, the studied assemblages from the late Early Miocene Trealla Limestone are considered to have lived within seagrass meadows under metahaline conditions (40–50 psu). Seagrasses are also indicated by fenestral structures (cavities, infilled by cement, perhaps caused by decaying rhizomes and leaves within the sediment) in the limestone.

The Trealla Limestone on the Southern Carnarvon Basin contains the oldest evidence for seagrass meadows in Western Australia. Extensive meadows were present on the Western Australian inner shelf from, at least, ca. 20.5–16 Ma.

8. Other Poster

Middle Eocene neritic limestone in the type locality of the volcanic Barique Formation, Timor-Leste: microfacies, age and tectonostratigraphic affinities with the north-western margin of the Australian continent

Zahra Karimi Mossadegh, David W. Haig, Justin H. Parker, Myra Keep

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Eocene shallow-water limestone is widespread in small isolated outcrops in Timor. Several occurrences of limestone in the Culocau River of Timor-Leste are significant because they lie within the type locality of the mainly volcanic Barique Formation. The tectonostratigraphic affinity of the Culocau River limestone is investigated by establishing the range of microfacies present (indicative of the inner neritic zone less than 40 m deep to the outer neritic Deep Euphotic Zone), the age of the limestone using planktonic and benthic foraminifers (late Middle Eocene, probably within the 37.8–43.6 Ma interval), and the similarity of the limestone–volcanic association to coeval occurrences elsewhere in Timor and the region. The field association of Middle Eocene neritic limestone with volcanic-volcaniclastic rocks is widespread in Timor, but is not known along the North West Shelf of Australia. Elsewhere in Timor the association of rocks found at the Barique Formation type locality also includes Late Eocene and latest Oligocene-earliest Miocene neritic limestone. This young, mainly volcanic association (Barique Group) is usually found in coherent areas of outcrop with the Late Mesozoic Palelo Group, oceanic facies (radiolarites to carbonate pelagites), Late Jurassic Bahaman-like carbonate-bank deposits (Perdido Group) and associated units of Gondwanan origin that form some high fatus surrounded by the Barique Group, and the Lolotoi/Mutis Metamorphic Complex. This is the Overthrust Terrane Association that is distinct in outcrop area and in lithostratigraphic makeup from the pre-collision Late Carboniferous to Middle Jurassic East Gondwana Interior Rift Association and the Late Jurassic to early Late Miocene Timor-Scott Plateau Association. The Cretaceous to Early Miocene units of the Overthrust Terrane Association, including the Barique Group, are similar to coeval units in Sumba and are considered to be fragments of the fore-arc of the Banda Arc. These units are distinct in terms of rock composition and provenance from formations of equivalent age on the north-western margin of the Australian continent and are considered to have been emplaced onto this margin during tectonic collision (commencing at about 8 Ma).

Presidents Dinner

University Club Banquet Hall, UWA

Saturday 28 July, from 6.30 pm

Presidents Dinner - Order of Proceedings

6.30 pm:	Guests arrive and pre-dinner drinks served
7 pm:	Guests are seated, beverages are served and orders taken
7.15 pm:	Welcome by President of the Society
7.30 pm:	Entrée is served
7.45 pm:	Medals presented by Professor Lyn Beazley, Vice-Patron of the Society: The Royal Society of Western Australia Medal awarded to Professor David Blair Doug Clarke Medal award to Mr Darren Hamley
8.15 pm:	Main course is served
8.45 pm:	Symposium Poster Awards announced by Dr Peter Baillie, Chair of the Judging Panel; and presentations to those award winners present made by Professor Lyn Beazley, Vice Patron of the Society
9 pm:	Dessert is served
9.20 pm:	Expression of thanks and acknowledgment of Symposium Sponsors by President of Society
9.30 pm:	Tea, coffee and chocolates are served
10. 30 pm:	Dinner concludes; guests depart

RSWA Medal Winners 2018

The Royal Society of Western Australia Medal

The Medal of The Royal Society of Western Australia was instituted in 1924 to mark the centenary of the birth on 26 June 1824 of Lord Kelvin, the distinguished mathematical physicist who was President of the Royal Society in London from 1890 to 1895. The medal is awarded every 4 years for distinguished work in science connected with Western Australia. The recipient shall, on the awarding of the Medal, be requested to deliver a public address to be Royal Society of WA known as The Royal Society of Western Australia Medal Lecture". There have been 24 distinguished recipients of the Medal from 1924 to 2010.

For 2018 the RSWA decided to award two medals, as none were awarded in 2014. We are pleased to announce the following distinguished scientists as RSWA Medal winners for 2018.

Emeritus Professor David Blair

Emeritus Professor David Blair is a leading experimental physicist. Born in 1946, David qualified in 1967 with a BSc with 1st Class Honours in Physics at UWA, and in 1972 with a PhD from East Anglia. From 1976 to 2000, for the site at Gingin near Perth, he led the development and operation of the first Southern Hemisphere gravitational wave detector NIOBE that operated in a worldwide array of 5 detectors, and associated research projects on ultralow noise transducers, ultra-stable sapphire oscillators, ultralow acoustic loss systems and vibration isolation.

From 2000 he led the development of the Australian International Gravitational Research Centre which includes the Gravity Discovery Centre at Gingin, a major public outreach centre for teaching Einsteinian Physics to schools and the general public to better understand our Universe. David has been an enthusiastic teacher and mentor at all levels from primary school to undergraduate teaching to postgraduate supervision and public education, including numerous international conference presentations, and participation in thirty radio and television broadcasts from 2008 to 2016. His pioneering research work, in collaboration with scientists in Australia and internationally, has led to an impressive list of achievements. David's work has been recognised with numerous awards including: in 1995 the Walter Boas Medal of the Australian Institute of Physics; in 2003 the National Medal for. Community Service, the Centenary Medal for Promotion of Science, and the Clunies

Ross National Medal for Science and Technology; in 2004 the Learning Links award of the Minister for Education and Training; in 2005 the ANZAAS Medal, and in 2007 the Western Australian Scientist of the Year Award. In 2014 he was elected Fellow of the American Physical Society. David's appointments include being Winthrop Professor at The University of Western Australia 1999-2017, Director of the Australian International Gravitational Research Centre 1994-2016, UWA Node Director ARC CoE for Gravitational Wave Discovery 2017-2018, and Emeritus Professor at The University of Western Australia 2018. On 20 June 2016 he delivered the RSWA Monthly Talk "The Universe has Spoken", details of which are on our website.

Emeritus Professor Barbara York Main

Professor Barbara York Main has been a pioneer and expert in the field of arachnology. Born in 1929 in Kellerberrin WA, in 1956 she was the first woman to receive a PhD in the Zoology Department of UWA, followed by the award of an Alice Hamiliton Fellowship. In 1958 she worked at the prestigious British Museum. Over her long career she has extensively travelled for field studies and to study spider collections in Australian museums and around the world. For seven years she was an Honorary Entomology Consultant at the Poisons Information Centre at Princess Margaret Hospital for Children. Since 1952, Barbara has had teaching experience at UWA with Lectureship progressing to a Professorship in 1996. Barbara's work on arachnids, including extensive publications from 1952 to 2012, a writer of four books, and a long list of coauthored publications, have brought spiders to the front of people's minds in terms of conservation and the sharing knowledge about them. Nineteen species of arachnid have been named in her honour. She has been a valued Trustee at the Western Australian Museum. Her appointments have included the Australian Biological Resources Study Advisory Committee and Centre International Documentation Arachnology (Paris). Barbara has been an inspirational role model for women in science, where her contributions in the fields of arachnology and biology more generally have been recognised by the award of the Order of Australia.

The Doug Clarke Medal

This award recognizes the outstanding contribution to science education made by Doug Clarke of Murdoch University. Doug joined Murdoch University as a founding Member and Senior Technician in the School of Mathematics and Physics (MPS). By the end of 1975 Doug had been promoted to Professional Officer to enable him to undertake independent research, demonstrate, lecture, and co-supervise honours and postgraduate students. During his time at Murdoch University Doug's work knew no boundaries. Doug was responsible for Occupational health and Safety, helped to establish a large number of courses, and was the major contributor to Laboratory Manuals, and lectured in many of them. Having performed hundreds of chemistry magic shows at schools and regularly appearing on television, Doug has

inspired thousands of school children, assisted thousands of undergraduate and postgraduate students and made an incalculable contribution to research and innovation.

We are pleased to announce that the Doug Clarke Medal for 2018 for Outstanding Contribution to Science Teaching at High School level is awarded to:

Mr. Darren Hamley (Willetton Senior High School)

Darren Hamley has been a science teacher at Willetton Senior High School since 1992. He has been integral in the education of gifted students for the past 19 years. To cater for the needs of our gifted and talented students, Darren uses a differentiated curriculum focusing on authentic science experiences. He devotes over 25% of his class time to teaching students to be scientists rather than just teaching them science. Our students thrive using this approach which has shown both in our data driven system as well as the achievement of aspirational targets for the students. Current projects designed and executed by current Year 7-10 students include:

- Construction and deployment of artificial nesting boxes with motion detection surveillance system to study the breeding of Black cockatoos and Major Mitchell's Cockatoos;
- A study of the echolocation patterns of dolphins to determine if they are copied by their offspring and a study of change in Monkey Mia dolphin echolocation bursts before and after being fed;
- Hydrodynamic drag testing of dolphins with dorsal fin damage using 3D printed replicas and mathematical modelling to determine the effect on dolphins of discarded fishing line;
- Construction, testing and deployment of electro-deposition artificial coral reefs to speed the regrowth of damaged reefs;
- Studying the brightest galaxy sources detected with the Murchison Wide-field Array
- Construction and deployment of baited remote underwater video devices to conduct fish surveys.

in 2016 when the school was undergoing a major rebuild, Darren initiated then submitted a successful application to build a school observatory. The observatory, which has just been completed, houses a fully robotic 36cm telescope which the students can access from home. The project has been a very long and complex task. The telescope will be used for astronomical research, astrophotography and for observation nights. Students from Darren's astronomy club have met once a week for the past four years to plan and build the observatory.

One of Darren's major achievements has been the solar car project. Darren initiated the solar car club in response to research indicating that our future engineering students lacked skills in hands on engineering. The group has met after school with a group of volunteer parents since 2007. They have competed in the Darwin to Adelaide World Solar Challenge on two occasions, and twice driven the car as a demonstration of sustainable transport across the Nullarbor. The car has recently been totally refurbished ready for a drive across Western Australia later this year.

Darren Hamley is prolific in his promotion of science and Science Education in Western Australia.

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INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

IUGS

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Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					present
Phanerozoic	Cenozoic	Quaternary	Holocene U/L	Meghalayan	0.0042
			Holocene M	Northgrippian	0.0082
			Holocene L/E	Greenlandian	0.0117
			Pleistocene	Upper	0.126
				Middle	0.781
				Calabrian	1.80
				Gelasian	2.58
		Neogene	Pliocene	Piacenzian	3.600
				Zanclean	5.333
			Miocene	Messinian	7.246
				Tortonian	11.63
				Serravallian	13.82
				Langhian	15.97
				Burdigalian	20.44
				Aquitanian	23.03
		Paleogene	Oligocene	Chattian	27.82
				Rupelian	33.9
			Eocene	Priabonian	37.8
				Bartonian	41.2
				Lutetian	47.8
				Ypresian	56.0
			Paleocene	Thanetian	59.2
				Selandian	61.6
				Danian	66.0
	Mesozoic	Cretaceous	Upper	Maastrichtian	72.1 ±0.2
				Campanian	83.6 ±0.2
				Santonian	86.3 ±0.5
				Coniacian	89.8 ±0.3
				Turonian	93.9
				Cenomanian	100.5
			Lower	Albian	~ 113.0
				Aptian	~ 125.0
				Barremian	~ 129.4
				Hauterivian	~ 132.9
				Valanginian	~ 139.8
				Berriasian	~ 145.0

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					~ 145.0
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	152.1 ±0.9
				Kimmeridgian	157.3 ±1.0
				Oxfordian	163.5 ±1.0
			Middle	Callovian	166.1 ±1.2
				Bathonian	168.3 ±1.3
				Bajocian	170.3 ±1.4
				Aalenian	174.1 ±1.0
			Lower	Toarcian	182.7 ±0.7
				Pliensbachian	190.8 ±1.0
				Sinemurian	199.3 ±0.3
				Hettangian	201.3 ±0.2
		Triassic	Upper	Rhaetian	~ 208.5
				Norian	~ 227
				Carnian	~ 237
			Middle	Ladinian	~ 242
				Anisian	247.2
			Lower	Olenekian	251.2
				Induan	251.902 ±0.024
	Paleozoic	Permian	Lopingian	Changhsingian	254.14 ±0.07
				Wuchiapingian	259.1 ±0.5
			Guadalupian	Capitanian	265.1 ±0.4
				Wordian	268.8 ±0.5
				Roadian	272.95 ±0.11
			Cisuralian	Kungurian	283.5 ±0.6
				Artinskian	290.1 ±0.26
				Sakmarian	295.0 ±0.18
				Asselian	298.9 ±0.15
		Carboniferous – Pennsylvanian	Upper	Gzhelian	303.7 ±0.1
				Kasimovian	307.0 ±0.1
			Middle	Moscovian	315.2 ±0.2
			Lower	Bashkirian	323.2 ±0.4
		Carboniferous – Mississippian	Upper	Serpukhovian	330.9 ±0.2
			Middle	Visean	346.7 ±0.4
			Lower	Tournaisian	358.9 ±0.4

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					358.9 ± 0.4
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	372.2 ±1.6
				Frasnian	382.7 ±1.6
			Middle	Givetian	387.7 ±0.8
				Eifelian	393.3 ±1.2
			Lower	Emsian	407.6 ±2.6
				Pragian	410.8 ±2.8
				Lochkovian	419.2 ±3.2
		Silurian	Pridoli		423.0 ±2.3
			Ludlow	Ludfordian	425.6 ±0.9
				Gorstian	427.4 ±0.5
			Wenlock	Homerian	430.5 ±0.7
				Sheinwoodian	433.4 ±0.8
			Llandovery	Telychian	438.5 ±1.1
				Aeronian	440.8 ±1.2
				Rhuddanian	443.8 ±1.5
		Ordovician	Upper	Hirnantian	445.2 ±1.4
				Katian	453.0 ±0.7
				Sandbian	458.4 ±0.9
			Middle	Darriwilian	467.3 ±1.1
				Dapingian	470.0 ±1.4
			Lower	Floian	477.7 ±1.4
				Tremadocian	485.4 ±1.9
		Cambrian	Furongian	*Stage 10*	~ 489.5
				Jiangshanian	~ 494
				Paibian	~ 497
			Miaolingian	Guzhangian	~ 500.5
				Drumian	~ 504.5
				Wuliuan	~ 509
			Series 2	*Stage 4*	~ 514
				Stage 3	~ 521
			Terreneuvian	*Stage 2*	~ 529
				Fortunian	541.0 ±1.0

Eonothem / Eon	Erathem / Era	System / Period	numerical age (Ma)
			541.0 ±1.0
Precambrian – Proterozoic	Neoproterozoic	Ediacaran	~ 635
		Cryogenian	~ 720
		Tonian	1000
	Mesoproterozoic	Stenian	1200
		Ectasian	1400
		Calymmian	1600
	Paleoproterozoic	Statherian	1800
		Orosirian	2050
		Rhyacian	2300
		Siderian	2500
Precambrian – Archean	Neoarchean		2800
	Mesoarchean		3200
	Paleoarchean		3600
	Eoarchean		4000
Hadean			~ 4600

Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Numerical ages for all systems except Quaternary, upper Paleogene, Cretaceous, Triassic, Permian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012), those for the Quaternary, upper Paleogene, Cretaceous, Triassic, Permian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World (http://www.ccgm.org)

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard, J.-X. Fan

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URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2018-07.pdf

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